

E S S A Y S

RELATING TO

AGRICULTURE

AND

RURAL AFFAIRS.



E S S A Y S
RELATING TO
A G R I C U L T U R E
AND
R U R A L A F F A I R S .

V O L U M E F I R S T .

THE THIRD EDITION, WITH LARGE ADDITIONS.

BY

J A M E S A N D E R S O N ,

FARMER AT MONKS-HILL, ABERDEENSHIRE.

And he gave it for his opinion, that whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground, where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together. SWIFT.

D U B L I N :

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W. SPOTSWOOD. MDCCLXXIX.



TO

WILLIAM CULLEN, M. D.

PROFESSOR

OF THE PRACTICE OF PHYSIC IN
THE UNIVERSITY OF EDINBURGH,

AND

FIRST PHYSICIAN TO HIS MAJESTY
IN SCOTLAND, &c. &c.

SIR,

THE favourable reception
given by the public to the first
edition of the following Essays
emboldens me to inscribe the
second to you. Justice, as
well as gratitude, demand this
of

ii DEDICATION.

of me : For, if there is any merit in the following performance, I have no hesitation in ascribing it to the impression that your judicious instructions have made upon my mind : If I were capable of forgetting the many obligations I owe to your tender solicitude for my welfare, when I had no other person to direct my youthful steps, I would, indeed, be unworthy of the attention you bestowed.

Accept, then, Dear Sir, of this small testimony of my gratitude
and

DEDICATION. iii

and esteem. I was afraid to offer it sooner, lest I might have dishonoured your name by prefixing it to a work unworthy of your patronage. It shall always be my study so to act as not to make you ashamed of the partiality you have shewn me. This is the only return in my power to make for all your kindness ; and, if I can fully succeed in this attempt, I am well assured it will be to you the most acceptable return I could give.

I shall

iv DEDICATION.

I shall always esteem it my
highest honour to be, with the
warmest affection, and most
grateful esteem,

S I R,

Your much obliged,

Most obedient, and

Most humble servant,

MONKS-HILL,

Aug. 1776.

J A^s. ANDERSON.

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A D V E R -

ADVERTISEMENT.

THE following Essays were written by the persuasion of the late ingenious Dr. John Gregory of Edinburgh, who always wished to turn the attention of mankind to the pursuit of what was solid and useful in arts and sciences, rather than to what might be more showy and unimportant: And, as the writer concurred entirely with him in opinion in this respect, he has aimed, in these Essays, rather to instruct the ignorant by a simple enumeration of a few well established facts, than to amuse the speculative by an idle display of useless ingenuity.

The first part of this book was nearly in the same state in which it now appears when that gentleman died, February 1773; since which time the author has found in himself little inclination to prosecute a subject, which he was chiefly prompted to undertake by the pleasure he had in doing what he thought might be agreeable to a friend he so much esteemed; and from the prospect of having his performance revised by one who would have been no less ready to have corrected the faults, than to have approved of what he might have deemed praise-worthy. But the manuscript having been carelessly allowed to be seen by several persons, and there being reason to suspect that it might be published under another form, it was judged proper to commit it to the press as it originally came from the hand of the author.

In this edition, several new articles are added, especially with regard to the rearing of hedges, which some of the
Author's

Author's friends thought necessary;—some notes, and other illustrations, are interspersed through the whole;—and accurate figures of the grasses and other plants recommended in the sixth Essay are given, which, it is hoped, will be of use to all readers, but especially to such as are not much versed in botanical researches; as it will enable them to know the several plants at sight. An entire Essay on the nature and properties of Quick-lime, is likewise added.—To the whole is subjoined an Appendix, containing upwards of two thousand experiments, made with a view to ascertain what plants are eat or rejected by the different domestic animals commonly reared in Europe, from the *Amoenitates Academicæ*.

These additions are so considerable, that the Author judged it necessary to cause them to be printed separately, and sold by themselves, that the purchasers of the former edition might not be put to any unnecessary expence.

If this work should go through another edition, the result of experiments, and such other small additions as may be necessary, will be given to the purchasers of this and the former edition gratis.

PREFACE.

P R E F A C E.

IT may not perhaps be looked upon as one of the smallest inconveniences attending the profession of Agriculture, that so many of the most conspicuous writers on that subject, having been themselves entirely unacquainted with the practice of that art, and of consequence unable to select with judgment from the works of others, have frequently copied their errors with the same scrupulous nicety as the most valuable parts of their works. And, as
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it usually happens that, when a man indulges his imagination, and creates to himself ideal plans of improvement, he can render them apparently much more perfect than any thing that really takes place in practice, it is but natural to expect that these plans should catch the attention of an unexperienced compiler; who being thus seduced himself, employs the utmost of his rhetorical powers to persuade his readers to adopt these particular practices. In this manner is the judgment of the young and unexperienced farmer but too often misled; and he is made to adopt peculiar opinions, and follow certain favourite

favourite practices with a persevering obstinacy that his own better judgment never would have allowed him to do, if he had proceeded with that attentive diffidence that always accompanies ignorance when attended with native good sense. So that, although books of that kind often contain observations that may be of very great utility to an experienced farmer, who may be able to distinguish between the good and the bad; yet, to those who have most need of instruction, and who ofteneft consult them, these books frequently prove the source of very capital errors: So that it would usually be better for such

farmers that no such books had ever been written.

The writer of the following pages strongly felt the inconveniencies here complained of, in the early part of his life, and would be glad if he could in any way contribute to prevent others from suffering in the same way. With this view, he has penned, at his leisure hours, the following Essays, on such subjects as have in the course of his practice particularly engaged his attention; and now offers them to the public in that native simplicity of dress in which he thinks truth ought always to appear. The observations contained
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in the following sheets are chiefly the result of his own experience ; but if, at any time, he has ventured to extend his views a little farther, with a design to turn the attention of the reader to a few other objects of importance, he has always taken care to inform him of it, that he may never be at a loss to know what degree of credit he ought to bestow upon every particular part. And, as he had no other aim but to afford a few plain instructions to the inexperienced reader, upon which he might safely rely without fear of being misled ; he has followed no other plan but to mark down with candour such facts relating

to the subjects that he has treated of, as he knew could be relied upon, or such observations as naturally flowed from these; without ever once proposing to give a complete treatise on any one subject, or being anxious in pursuit of novelty, or solicitous about collecting whatever others may have said concerning it. The proper business of a farmer is to furnish facts to others, and not to pilfer from them; and he thinks it would tend much to the advancement of this art, if men of knowledge and experience in any branch of Agriculture would be satisfied with communicating to the public

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lic such useful facts as they may have been enabled to ascertain with regard to that particular branch of their art, without endeavouring to extend their observations to every other branch thereof, or thinking it a duty incumbent upon them to give a physical investigation of the cause of every phaenomenon; which too often tends to divert the mind from attending to useful facts, and to lead it, in search of a phantom of the brain, into the inextricable mazes of error. For, although a Bacon or a Newton may sometimes appear, whose towering genius is capable of taking a comprehensive survey

survey of nature,—of comparing the dependence that each part has upon another, and the relation it bears to the whole,—of tracing out the laws by which they are united or disjoined, and of thus exalting an art into a science; yet, as there are but few who are thus peculiarly favoured by heaven, it is becoming in others who have reason to feel that they are not possessed of such superlative abilities, to be more humble in their aim, and to content themselves with moving in a less exalted sphere. Yet how natural is it for man, whose heart is ever susceptible of the impressions of vanity, and whose mind
must

must always be delighted with that sublime beauty that results from a knowledge of nature, to be ready to indulge himself a little too freely in researches which coincide so well with the natural bias of the mind! Let him who has not erred in this way criticise with asperity the failings of his brethren: It does not belong to me. For, when at times I have been tempted, by some concurring facts, to think that I had got a glimpse of some fundamental law, the knowledge of which brought order from confusion;—when the imagination has been fired, and I have been ready to enter an unbidden guest into the sacred temple

temple of science ;—when I was ready in my own imagination, to withdraw the mysterious veil that covers nature's works ;—when I stretched forth my hand—methought I heard a voice, which, with awful solemnity said, MORTAL, KNOW THYSELF,—BE HUMBLE.—Confounded at the just reproof, I started from my dream, and with an humble mind, resolved discreetly to pursue the inferior path that nature had assigned me,

Purity of language will not be looked for in a treatise of this nature. A man educated in a remote province,

vince, at a distance from men of letters, in a great measure deprived of the use of books, and attending more to the objects of his profession, than to the delicacies of style, cannot be expected to write with that purity that might be required in a book of mere amusement. It is the matter rather than the form that ought to constitute the principal merit of every didactic performance. And, as the writer hereof knew that it would be in vain for him to expect to arrive at a classical elegance of language, it has been his principal aim to convey his meaning to the reader in the clearest and

and most distinct manner that he could, without any attempt at ornament. He observes, however, with regret, upon perusing his book, that the great attention he has bestowed to render every thing he says intelligible to every capacity, has introduced into his style, a certain languor and diffuse prolixity that is extremely disagreeable to himself; and doubts not but many of his readers will find it much more disgusting to them; but he finds, at the same time, that it requires different talents to perceive a defect, and to be able to correct it properly. However, as he has not wilfully offended,
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he hopes for the indulgence of the candid reader in this respect.

He is, nevertheless, sensible that he has not rejected with such scrupulous nicety all provincial words as some may wish he had done; some of which he has even knowingly inserted, because he was not so well acquainted with the language as to have been able to have conveyed his meaning in such a determinate or easy manner without them. This he was likewise in some measure induced to do, from having frequently observed, that such inexperienced scriblers as himself,

by

by too studiously avoiding to employ every word that they could not meet with in their dictionaries, have given to their writings an air of pedantry and affectation that is extremely disagreeable; and, which is worse, by being obliged to employ other words in their stead, the precise meaning of which they have not been able exactly to learn, they have helped to debase our language, by introducing a vague and indeterminate application of phrases, which he deems an evil of far greater consequence than that they endeavoured to shun. On these accounts he has always employed such words

as

as he found conveyed his idea in the easiest manner, without being anxiously solicitous to examine whether they were much in fashion or not: Always taking care, however, to mark at the bottom of the page, the precise meaning of every uncommon word that he was conscious of employing. Some readers may perhaps be disgusted at this, while others may possibly think, that, as every other art has some particular terms appropriated to itself, which could not be rejected without occasioning great circumlocution or inaccuracy when treating of it, so must agriculture have some peculiar to it,

it, which ought not to be expunged from the language; and that, therefore, they would find fault with no word that conveyed a distinct idea to the mind, if the meaning of it was duly explained, and if it could not be exactly supplied by any other standard-word of the language.

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VOL. I.

B



RURAL AFFAIRS

AND

AGRICULTURE

E S S A Y I.

OF

INCLOSURES AND FENCES.

THE uses and value of inclosures are now so generally understood, that it will not be necessary to say any thing upon that head in this place. I only propose, in this essay, to make some observations on the principal uses, comparative value, and manner of rearing several kinds of fences, with a view to enable the young farmer to make choice of such kinds as may best answer the purpose that he may desire.

§ I.

Comparative Value of Dikes and Hedges.

The fences that are most universally employed, are either stone-dikes or hedges*. Dikes, if well built, as effectually preserve a field from the intrusion of domestic animals, as any other kind of fence whatever; but they afford little warmth or shelter to the field: Whereas hedges, if good, answer both these purposes equally well. But the most material distinction between dikes and hedges is, that dikes are in their highest degree of perfection as soon as they are reared, and from that moment begin to decay; so that the person who builds this kind of fence immediately receives the full benefit of it; whereas hedges, being at first weak and tender, stand in need of attention and care, and do not become a fence for several years after they are planted. And, as they continue to encrease in strength, and gradually acquire a higher and higher degree of perfection, it is long before they begin to fall toward decay; so that they are, in general, infinitely more durable than dikes, although they are longer of becoming of use to the person who plants them.

Which of these two kind of fences may, upon the whole, be most eligible, must, in general,

* Dike is a term employed in the following Essays, to denote any kind of wall reared for the purpose of inclosing a field, and nothing else.

neral, be determined by the circumstances and views of the possessor of the ground to be inclosed. If he is a tenant who has a short lease, without a prospect of getting it renewed, or, if he has immediate occasion for a complete fence, it may perhaps, in general, be most prudent in him to make choice of dikes, if the materials for rearing these are at hand; but, if it is probable that his posterity may reap any advantage from these inclosures, it will be almost always more for his advantage to make choice of hedges.

§ II.

Of dry Stone-Dikes.

If you live in a country where good free stone can be easily got, and lime procured at a moderate price, a dike built of these materials will, it is true, be almost as durable as a hedge; although, in general, it will neither be so cheap nor agreeable. But dry stone-dikes, unless built of the finest quarried stone, are of such a perishable nature, as to be hardly ever worth the expence of rearing; and never, as I apprehend, excepting where the field that you would wish to inclose has plenty of stones upon its surface, which you are under a necessity of carrying away before the field can be improved. In this situation, a man may, in some measure, be excused, if he should be tempted

tempted to put them into dikes; because the carriage of these stones may be said to cost him nothing; and he may, perhaps, be at some loss how to dispose of them in any other manner. But, in all other circumstances, I apprehend, that it is very bad oeconomy to rear fences of this kind, as *feal* * dikes can always be built at about one fourth of the expence that these would cost—will answer all purposes equally well; and, if carefully built, may be kept in repair for any number of years at as small an expence as they could be.

§ III.

Of feal, or earthen Dikes.

As feal-dikes are common enough in some parts of this country, and are not, in many cases, so durable as I would seem to insinuate; and, as this is, in general, owing to the faulty manner in which they are built, it will be proper for me here to explain the manner in which these

* *Feal* is a provincial word, which may perhaps have many synonyma. It here means any kind of sod dug by the spade from the surface of grass-ground, consisting of the upper mold rendered rough and coherent by the matted roots of the grass thickly interwoven with it. If only a very thin bit of the upper surface is pared off with a paring spade, the pieces are here called *Divots*. These being of a firmer consistence, are more durable when built into dikes than *feal*, but much more expensive also.

these dikes may be built, so as to stand much longer than they usually do.

The greatest part of the dikes of this kind, that I have seen, are made of a considerable thickness, with a ditch on each side; the heart of the dike being made up with the earth that has been taken from these ditches, and only a thin wall, on each side, is built of solid *feal* from top to bottom; the consequence of which is, that, as the loose earth that is thrown into the middle of the dike subsides much more than the *feal* on each side, the top of the dike sinks down, and, of course, the two side-walls are pressed too much upon the inside, so as to *bilge* (swell) out about the middle, and quickly crumble down to dust. To avoid this inconvenience, I have always chosen to build my dikes of this sort much thinner than usual, they being only three feet and a half thick at the bottom, one foot, or a very little more, at top, and five feet high, taking care to have them built in such a manner, as that every sod, (*feal*), from top to bottom, binds the joinings of the others below it, with as much accuracy as the bricks in a well built wall; as will appear by examining and comparing together (Fig. 1st.) which represents a perpendicular section of this dike; (Fig. 2d.) a side-view of the same; and (Fig. 3d.) a perpendicular view of each row as it lies in the dike.

The

The manner in which the workman proceeds, so as to effectuate all these joinings with the utmost accuracy and facility, is as follows: He begins by making a long rut, *xx* and *xx* (Fig. 3d.) with his spade, along each side of the dike, turning his back towards the place where the dike is intended to be, so as to make the cut of the seal slanting outward, as at *xx* (Fig. 1st. and 4th.): He then makes another rut, a *z*, (Fig. 3d.) parallel to the former, at the distance of the length of the seal *a* from it, keeping his face towards the dike, so as to slope inward, as at *R* (Fig. 4th.), which is necessary, that the first row of seal may be allowed to be raised up with freedom. It is then cut into fods of a proper breadth, as at the dotted lines *a* (Fig. 3d.), which being raised up by the spade, are then laid into the dike, with the grassy side undermost, as at *a* (Fig. 1st. 2d. and 3d.); the same letter always representing the same seal, as viewed in different directions. The other side being finished off in the same manner, the upper surface of the whole course of seal is pared smooth, and clapped down with the back of the spade, to prepare it for receiving another course above it. Another row of seal, *b z*, (Fig. 3d.) is then marked off, at the distance of the breadth of that at *b*, (Fig. 1st. and 3d.) from the former, the workman keeping his face still towards the dike; and the through-band seal *B*, on the opposite side, having

ing been first rightly laid, this is put a-cross the ends of these length-ways, so as to form a side-band, *b* (Fig. 2d. and 3d.) Another rut, *c z*, is then made, at the distance of the length of the feal *c* from the former; but, before it be raised, it is necessary to draw a rut in the line *b z*, with the back of the workman towards the dike, which gives it the form BAC, (Fig. 4th.) leaving a small triangular piece at S; so that, when it is put upon the dike, it at once assumes the position as marked at BAC, and thus allows the opposite side-band O to join quite closely to it; whereas, had it not got the rut at B (Fig. 4th.) it would have projected outward above, as at D; so that the feal O could not have joined it closely, but would have left a triangular opening in the heart of the dike, as marked in the two courses of feal below this, which would make the dike far less solid and compact than it is when managed in this way. In this manner the workmen proceed, always rutting the through-band rows of feal in both ends, but the side-bands only on one side, beginning every course with those which go a-cross the dike; so that, if the measures are taken exactly, and the whole be rutted by the line, they may work with the utmost freedom; and every feal will join to the others at the first with the utmost accuracy and facility. The uppermost course of feal is cut a little longer than those that are immediately below it, and placed with

with the grassy side uppermost, so as to project a little on each side, as may be seen at L L, (Fig. 1st.) which is not only of use to throw the water a little off the dike, but is also of use in preventing sheep or cattle from attempting to jump over it so readily as they otherwise might do. At the foot of the dike, on each side, is dug a small ditch xx (Fig. 1st.) about a foot and a half, or two feet deep, leaving a ledget of a few inches broad on each side, that the dike may not be undermined by the crumbling down of the loose earth into the ditch. These ditches not only help to give the dike an additional height, and keep its foundation dry, but are also of use to prevent cattle from coming close to it, and rubbing upon it, or tearing it down with their horns, which they are very apt to do, if this precaution be omitted. The earth that is taken out of the ditches may be thrown outwards into the place that was occupied by the seal that has been taken to build the dike; and, if the field is in grass, a few seeds may be sowed upon it, and it will soon be covered as well as the rest of the field.

I have been the more particular in describing the manner of forming these dikes; because, by having the joints bound in every direction, the fabrick is rendered much firmer than it could be by any irregular manner of working, while it is, at the same time, more easily reared. And, as experience has taught

me

me the easiest method of working these, which others might not, perhaps, have fallen upon at first, I thought it would be of use to communicate this to the public. If the ground is soft, and the seal rises well, I get a fence of this kind done for one penny halfpenny *per yard*; but, if it is not good to work, a little more than that must be allowed.

As to the time that a fence of this kind may stand without needing any repair, I cannot speak with certainty, as it is not long since I fell into this method of building them. The oldest has just now stood ten years, and seems to be nearly as firm as when first built. I have seen some walls of mean cottages that have been built somewhat after this manner, that continued to be good after standing forty or fifty years: But their durability, in a great measure, depends upon the nature of the seal of which they are formed. The best is that which is taken from poor ground, of a spongy quality, which is generally covered with a strong sward of coarse bent grass. And, in situations where this can be had, I have no hesitation in recommending this as the cheapest and best temporary fence that can be reared.

The greatest inconvenience that attends this species of fence is the danger it runs of being torn down by the horns, or wasted away by the rubbing of cattle upon it, which they will sometimes do, even where the ditches have been

been properly formed. This may be effectually prevented, by planting a row of sweet-briar (Eglantine *) plants between the first and second course of *feal* when the dike is building, which will not fail to grow with luxuriance, and in a short time defend the dike from every attack of this kind. But, if sheep are to be kept in the inclosures, this plant ought not, on any account, to be employed; for, as that defenceless animal naturally flies to the fences for shelter in stormy weather, the prickles of the straggling branches of the briar will catch hold of the wool, and tear it off in great quantities, to the great detriment of the flock, and loss of the proprietor. In these cases, if the possessor of the ground is not afraid of the bad consequences that may be dreaded from the spreading of *whins*, (furze), it would be much better to scatter a few of the seeds of this plant along the

* As this plant forms a most useful assistant to many others in fencing, I shall probably have occasion to mention it in some future parts of this Essay: I shall, therefore, in this place, mention the method of rearing it. Let the berries, or hips, as they are usually called, be gathered when ripe, and pitted in the ground like haws, or other kernelled seeds, for one year, and sowed in the ensuing spring in a bed of light rich garden-mold; they will quickly appear, and, as they grow very fast, some of the strongest of them may be taken up the first winter, and planted where they are to remain. All the others may be planted out the winter after that; so that they require but short time and little room in the nursery, and are, therefore, reared at a very small expence.

the ledget xx, (Fig. 1st.), at the foot of the dike, which would quickly become a preservative for it, and be otherwise of use as a green food for his sheep during the winter season. But, before he ventures to sow this plant, let him remember, that, where it is once established, it will hardly fail to spread through the adjoining fields, and can hardly ever afterwards be thoroughly rooted out.

I have often imagined, that this kind of fence might be greatly improved, both in beauty and strength, by planting a row of ivy plants beneath the first course of seal in building the dike, which would, in a short time, climb up the sides of the dike, and cover the whole with a close and beautiful net-work of woody fibres, covered with leaves of the most beautiful verdure, which would tend to preserve the dike from being eat away by frost *, and other vicissitudes

* It is generally allowed, that all the phænomena produced by what we call frost, are entirely occasioned by a certain degree of cold; and that, of consequence, if we by any means exclude the cold, we effectually guard against the effects of frost. If this is the case, we would naturally expect, that those things alone would preserve other objects from the effects of frost, that did most powerfully exclude the cold; yet, it is found by experience, that a very thin covering of straw, or other small and light vegetable twigs, carelessly strewed upon any thing, prevents the effects of frost in a much more powerful manner than almost any kind of solid covering of much greater depth, even where it is so close all around
as

situdes of weather. And, when it arrived at the top, it would there send out a number of strong woody branches, forming a sort of hedge, that would afford some shelter to the fields, and break the force of the wind considerably; but, as I never yet had an opportunity of trying the experiment, I only here offer it as a probable conjecture. I have seen a garden wall, that had been built of stone and clay, ornamented and strengthened in this way. I have had the experience of ivy growing very well upon a dry stone-dike; and have likewise seen it growing up the walls, and covering whole cottages built of seal, which have, by this means, been preserved intire long after other naked walls of the same kind have fallen to decay. But, not having had plants of this kind at hand, I have not had an opportunity of trying it in the manner proposed; although, I think, there is the greatest reason to hope for success *.

§ IV.

as to exclude all access to the air. I leave this phenomenon to be accounted for by naturalists; and would only here remark, that, from repeated observations, I am pretty certain of the fact; from which I conclude, that the leaves of the ivy would powerfully preserve the wall from the effects of frost.

* Since writing the above, I have met with Dr. Hafslequist's voyages, who describes, in the highest terms of rapture, the beautiful appearance of the garden-walls all around Smyrna entirely covered with ivy. He does not specify the materials of which these walls are composed, but, it is probable, they may be various. His observations,

§ IV.

Of white Thorn-Hedges.

THE fences before mentioned may be employed upon particular occasions; but, in general, hedges must be considered as of much greater value, and therefore, with justice, demand a more particular share of our attention and care.

Many plants have been successfully employed for hedging; but, among these, the common white thorn is justly esteemed the most valuable in this country, as it possesses, in a more eminent degree than any other plant common with us, the requisite qualities of quickness of growth, strength, prickliness, durability, and beauty. It will, therefore, be proper to make some remarks upon the method of training this valuable plant, before I take notice of any other.

§ V.

Of the most eligible Method of planting these.

IT may, in general, be remarked, that a hedge of thorns which has been planted in the
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ons, at least, show the practicability of what I have recommended. Ivy may be propagated by cuttings; but, it is probable, that they would require to be well rooted in garden-mold before they were planted out for good.

face of a ditch, thrives better than when planted in any other way; and that, on the contrary, this plant almost never thrives so ill, as when put upon the top of a bank faced with stones. This last method, therefore, ought to be avoided as much as may be; and the first be practised in all cases where it can conveniently be done.

Of those who practise this method of planting a hedge, some plant only one row of thorns, while others prefer a double, and others even a triple row, placed at different heights in the face of the bank; putting the plants in each of these rows opposite to the interstices of the other rows. But, as either the double or triple rows are attended with the inconvenience of not easily admitting either the hand or tools to clean them after the first year, the single row ought always to be preferred, except upon such soils as are quite free of weeds. For, if these spring up, and are allowed to grow without molestation, the hedge will be quickly choaked up with them, and stunted in its growth. Indeed, I am of opinion, that the single row is almost, in all cases, the most eligible; as it is not only more easily cleaned, but likewise, for the most part, advances with greater vigour, and becomes, at last, a stronger and a better fence than where more rows are planted; although these last have usually a more promising appearance for the first year or two.

§ VI.

Of the choice of a proper Soil for a Nursery of white Thorn-Hedges.

ALMOST all writers on agriculture, advise the farmer to be very careful to make choice of such plants only as have been raised in a nursery of a poor soil; and always to reject such as have been reared in a richer soil than that in which he is to plant them; 'Because,' say they 'a plant which has been reared in a barren soil, has been inured from its infancy to live hardly, and will advance with a great degree of luxuriance, if it is planted in one that is better; whereas a plant, that has been nursed in a fertile soil, and has suddenly rushed up to a great size, like an animal that has been pampered with high feeding and swelled up with fat, will languish and pine away if transplanted to a more indifferent soil.'

It would be no difficult matter to show the fallacy of this mode of reasoning, and to point out many errors which have crept into almost all sciences, from pursuing such fanciful analogies between objects in their own nature so different as in this example. But, as this would be, in some measure, foreign to my aim in this essay, I shall content myself with observing, that it could seldom be attended with worse consequences than in the present case, as it leads to a conclusion directly the reverse of what is warranted by experience. For, I have found, from reiterated experiment, that a

strong and vigorous plant, that has grown up quickly, and arrived at a considerable magnitude in a very short time, never fails to grow better after transplanting, than another of the same size that is older and more stunted in its growth, whether the soil in which they are planted be rich or poor; so that, instead of recommending a poor hungry soil for a nursery, I would, in all cases, wish to set apart, for this purpose, the richest and most fertile spot that could be found; and, in the choice of plants, would always prefer the youngest and most healthy to such as were older, if of an equal size. I speak here from experience, and, therefore, do it without the smallest doubt or hesitation; being certain that future observations will confirm the justness of these remarks.

§ VII.

Directions for managing the Plants while in the Nursery.

It has been hinted above, that, if the plants have been so managed as to have their roots very much multiplied close by the stem, it will tend greatly to make them prosper well after they are transplanted. But, as this is a circumstance of much greater importance than is in general apprehended, I shall beg leave to call the attention of the reader to it in a more particular manner.

It

It was long imagined, that roots imbibed nourishment from the earth throughout their whole length, as it was apprehended, that the watery juices penetrated the bark at every place, which acted as a filtre, or very fine strainer, and served to prepare the sap for entering into the finer vessels of the plant. But the experiments of Du Hamel, Bonnet, and others, have now sufficiently demonstrated, that little or no moisture is imbibed through the pores of the bark of roots; but that the whole nourishment of the plant is absorbed at the extremities only of the smallest ramifications of the roots. Hence, then, it follows, that the more numerous these small ramifications are, the more numerous will be the mouths of the plant, and the nourishment imbibed by them will be, in proportion, more abundant. But, if a plant be allowed to remain undisturbed for any length of time in a good soil, its roots will be extended to a considerable distance around it, at the extremities of which roots will be found almost all those mouths that imbibe the juices that nourish the plant; so that, when these extended roots are cut off near the stem, as must happen when the trees are to be transplanted, almost all the small fibres are cut away, and the roots remain almost entirely destitute of mouths; which tends in a most powerful manner to check the vegetation of the plant at that time, so as to stint it in its growth, and to make it languish ever afterwards.

But if, by a judicious management while in the nursery, the roots had been prevented from extending to any considerable distance, and had been forced to divide into numerous ramifications near the stem, fewer of these small roots would have been cut off when it was transplanted, and the inconveniencies above enumerated would have been in a great measure obviated.

Many improving farmers seem to be sufficiently aware of the good effects that result from this cause, and therefore are disposed on all occasions to prefer well rooted plants (that is, plants that have many small fibres at their roots) to such as are barer of small fibres. And, as it often happens that plants which have been reared on a poor soil, by being unable to penetrate it with ease, are compelled to branch out into more numerous ramifications near the stem than those that have grown upon a richer and easier penetrated mold, these first, altho' poorer and more stunted plants than the others, merely on account of their better formed roots, are preferred to them; and often succeed as well, and sometimes even better, than the others do. From which circumstance, some may imagine that the directions above given, with regard to the choice of plants, is erroneous. But, as it is possible to have the roots equally well formed, and the plants much more healthy on a rich than on a poor soil, it behoves

behoves those who wish to rear hedges in the most easy and perfect manner, to attend to this circumstance with the most careful circumspection.

As some persons imagine that the young thorns are greatly hurt by being transplanted in the nursery, to prevent the necessity of doing that, they sow the seeds at first in rows, in which they suffer them to stand till they are planted out for good. But this is an exceeding improper practice. For, if a thorn is suffered to remain long where it is first sowed, the tap-root descends to a great depth, without sending out a sufficient number of lateral shoots near the surface; so that, when it is afterwards taken up, to be planted in the hedge-row, it has few or no small roots that can be raised with the plant, which subjects it in a very high degree to the inconveniencies above enumerated.

To obviate these inconveniencies in some measure, it is always proper to transplant the thorns when young; at which period the roots ought to be shortened with a sharp knife, which will force them to send out a number of small ramifications, in the same manner as we see happens with the branches of a tree when these are lopped off.

The usual method of sowing thorns in a bed pretty thick, is as good a practice as can be followed, if the young thorns are transplanted from

from it in proper time. If the soil of the nursery be sufficiently rich, some of the strongest plants ought to be drawn from it the first winter after sowing; and the remainder ought only to be suffered to remain in the seed-bed one year longer. For, if the young thorn should be allowed to attain any considerable magnitude before this operation, the proportion of roots that it would then lose would be so very great, as would endanger the future health of the plant; which will not be the case if the plants are very young. For which reason, this necessary operation ought on no account to be deferred longer than till the second winter after the plant appears above ground.

Nurserymen, in general, transplant their thorns from the seed-bed at two years old, and plant them into rows about a foot or sixteen inches from one another, and keep them clean ever afterwards, by means of the hand-hoe. In consequence of being thus transplanted, the roots are a little shortened, which is of some service to them: So that transplanted *quicks*, if of the same age and vigour, will always be better plants than such as have been allowed to remain in the seed-bed. But, if these thorns remain above a year or two in the nursery after they have been transplanted, their roots extend to a great distance, so that, before they have attained the due size, they will be far beyond the proper limits; and, by intermixing with
one

one another through the whole soil, they soon exhaust it of all the nourishment it contained, which stints them in their growth before they have attained the magnitude required.

But, instead of planting them at this time in rows only twelve or sixteen inches a-part from one another, as is usually done, I would advise that the rows should be five or six, or, at the least, four feet distant from one another, which will allow all the operations necessary for forming the roots to be properly performed; and the plants will be supplied with such abundant nourishment as to keep them always in a state of very vigorous vegetation.

Nor will the frugal nursery-man lose any thing by allowing such a distance between the rows as is here prescribed: For, if the ground is in the high order that has been recommended, it will be in a condition to carry, between the rows, any sort of garden-plant that he may incline, in almost as great abundance as if no thorns had been planted on it. The only caution necessary to be given in this case, is, to avoid sowing any high growing plant upon these intervals for the first year or two, lest they should over-top the young thorns, and hurt their growth. If the soil is fit for carrying onions, that would be a very proper crop for the first year: Or, if this shall be thought improper, dwarf-pease, or any other low growing annual plant, that may best suit the circumstances

cumstances or situation of the possessor, may be sowed in their stead.

But, whatever crop shall be put upon the ground the first year after the thorns are transplanted, it is necessary that it should be at all times kept quite clear of weeds. In the succeeding winter, the earth between the rows ought to be dug over with the spade, taking care to go very close to the rows, and to work with a very sharp edged tool, so as to cut the greatest part of the lateral roots as near the body of the plants as may be, which will tend to make them branch out into still more numerous ramifications. And, if the ground is dug every winter afterwards, keeping at a little greater distance from the plant at each successive digging, the roots will be kept at all times so short, and their ramifications will be so numerous near the stem, that, when they shall be lifted to be put into the hedge, they will not fail to be provided with such an abundance of mouths to imbibe nourishment with, as to be in no danger of suffering much by that operation.

If the soil of the nursery is sufficiently rich, and if the thorns have been transplanted while young, and early in winter, they will rush up chiefly in height, and send out but few lateral branches; which is a thing much to be wished for in a nursery; therefore care ought to be taken, when they are transplanted, not to bruise

or

or injure the stem of the plant, nor, on almost any account, to cut it over, unless the stem was before nirlly and stunted. Neither ought the upright shoots to be, in any case, shortened while in the nursery: But, to facilitate the operations between the rows, any straggling side-branches that may spring out, ought to be cut off by the knife or shears at the beginning of winter.

In every situation, it will be proper that the earth between the rows be stirred the first winter by the spade; but, if the nursery is of great extent, it may be afterwards done by means of the plough, with the utmost facility.

The course of crops that would seem to be the most eligible, would be as follows:

1st Year, Dwarf-pease or onions.

2d, Early turnips, or colwart plants, if there is a demand for them on the spot; and, after these come off the ground, winter turnips.

3d, Early pease, and, as a second crop, winter turnips.

4th, And every succeeding year, early pease and turnips.

The reason why I would advise pease so often is, that this is a meliorating as well as a very profitable crop, and would be peculiarly proper in the present case. For, as the young thorns would soon attain a considerable height, they would afford much shelter to the ground, and bring the pease forward pretty early in the season.

season. And, if a row were sowed on each side of every row of thorns, at a foot or sixteen inches from them, there would be sufficient room to hoe the interval between them and the thorns, so as to keep down the weeds with little trouble; and, when the pease grow so high as to need support, they could be laid towards the hedge, which would answer the purpose of stakes perfectly well, and admit of their being pulled with the utmost facility.

If these pease are of the early sort, and the soil and situation favourable, they may be off the ground in sufficient time to admit of rearing in perfection a crop of winter turnips upon the same ground. And, as this plant serves to meliorate the ground more than almost any other, there is little doubt but the nursery could be kept, for any length of time that could be necessary, in very high order, by this succession of crops, without almost any expence of manure whatever.

By this, or some similar mode of management, the nursery will always afford its owner very profitable crops, and the thorns will be reared to the utmost perfection, and have their roots formed as properly as could be desired, at little or no expence. But, as it is impossible to purchase such plants as these from an ordinary nursery garden,—and, as the young thorns always suffer very much by being long kept out of the ground, not to mention the expence that

that would attend the transporting such large plants from any considerable distance, it is of much consequence for every improving farmer to rear plants for himself: Or, if he buys them at all from a nursery, to take them when only one or two years old, and nurse them afterwards for himself.

The only thing that can make the plan here proposed miscarry, is the neglecting to make the nursery rich enough before the thorns are planted in it; for, I have frequently observed, that gentlemen in the country, or farmers, who are at a distance from manures, err exceedingly in this respect. I therefore again repeat it, that it is *of the utmost consequence*, on all occasions, to have the nursery as rich as possible. And indeed, unless this be the case, he who shall attempt to rear thorns in the manner above described, will certainly be a loser, and, therefore, had better not attempt it at all, than do it in an imperfect manner: For a poor soil could never produce to advantage the crops above enumerated. But, if the ground is once put into proper tilth, it may be continued as a nursery ever afterwards, without almost any expence at all.

To put the ground into that high tilth, the year before you intend to turn it to a nursery give it a fallow in the beginning of summer, and a very thick dressing of dung—and lime if it needs it, and take a crop of winter turnips.

This

This will clean, enrich, and mellow the soil. If it has been in good order before, this will be sufficient; but, if the soil was naturally poor, it may be proper to repeat this same dressing a second year, which will assuredly effect the purpose. Starve not your plants at first; for the richer your soil is at first, the more quickly and abundantly will it repay you.

§ VIII.

Rules for choosing the Plants.

If you wish to have a good fence, free of gaps, and of an equal degree of strength throughout, pick your plants with great care, so as to have them all as nearly as possible of one size, and of an equal degree of healthiness. But, if you should have occasion for so many plants at one time, as makes it necessary for you to take them as you can find them, you had much better assort them into several lots of different sizes, and plant each of these lots in a place by itself, than plant the whole promiscuously; it being much better to have two inclosures fenced with hedges of different degrees of strength throughout their whole extent, but equal in every part, than one which is in some places stronger than in others; because, so long as any one part of it is weak, all the stronger places can be of no use as a fence; and if, with a view to remedy that evil, you plant your
weak

weak plants by the side of the strongest, they are apt to be overtopped by these, and stunted in their growth; so that the hedge, in these places, continuing always weak, is liable to be broke down by cattle, hogs, &c.; which occasions these unsightly and irremediable gaps that farmers so generally have reason to complain of. But, if all the plants are at first quite equal, their first shoots will be nearly equal in vigour, and will continue to advance at the same rate, so as to form a hedge equally strong in every part.

§ IX.

Of the proper Size of Plants.

If the young thorns are of an equally healthy temperament, the vigour with which they advance will be nearly in proportion to the size of the plant; so that it is of great consequence that these be not too small. The least size of thorns that I think should ever be planted out, if the plants can be got, should be such as are about the bigness of a man's little finger; but they will be better if about the size of the thumb. If plants are reared in a very rich nursery, till they are of this size, and have had the earth carefully dug about them each year, so as to make them have their roots very much multiplied close by the stem, and be planted in a good soil in the manner after mentioned, few persons

persons have any comprehension of the degree of vigour with which they will advance. In such a case, the farmer may reasonably expect that the shoots of the first year will be, at a medium, between three and four feet in length, and some of them considerably beyond that. It would be difficult to rear plants to a larger size than this in a nursery; and, although they may be sometimes got of a larger size, by grubbing up a hedge which it is necessary to remove; yet as, in this case, the roots have been allowed to extend to a greater distance when growing, there is a necessity of cutting off many of these at raising them, so as to leave but few fibres adhering to the plant; on which account, it is not to be expected, that they will advance so fast as plants of a smaller size, which have had their roots properly formed by a judicious management in the nursery; yet plants of this kind ought not to be rejected, as I have sometimes seen them send out shoots of very great strength and vigour.

§ X.

Of the proper Season for planting these.

As the strength and future healthiness of a hedge in a great measure depend upon the vigour of the shoots it makes the first year, too much care cannot be taken to guard against every circumstance that may tend to retard its progress

progress at that period. On this account, it is of very great consequence, to have every hedge planted as early in winter as possible. For, I have found, by long experience, that, if one part of a hedge has been planted early in winter, and another part of it in the months of March or April, when the buds begin to swell, all other circumstances being equal, the shoots of the first year, from that part which has been first planted, have always been nearly double the size of those of *the other part*, and continue ever afterwards to be more healthy and vigorous in every respect; which is a circumstance that few, who have not experienced it, would naturally have expected. If the spring be not very backward, thorns should seldom be planted after the beginning of February; and, in the most backward seasons that we ever experience, none should ever be planted after the beginning of March, if it can possibly be avoided. It is a good method, in general, for those who have a great deal of work of this kind to perform, to begin to plant early in autumn; taking only so much earth from the ditch at that time, as is necessary to cover the roots of the plants sufficiently; and running along the whole in this manner as quickly as possible, so as to have the quicks all planted early in winter; after which the ditches may be finished, without any loss, in the spring. But, even in this case, the whole ought to be finished in the month

month of March, otherwise the young shoots will be much injured by the disturbance they will meet with.

§ XI.

Of Trimming before Planting.

As the vigour of the first shoots of a hedge, likewise, in a great measure, depends upon the proper trimming of the young thorns before planting, I shall beg to make a few observations on that head.

Every tree, when it is transplanted, loses a part of its roots, and is on this account unable to absorb so much nourishment as would be necessary to make it push out shoots with an equal degree of vigour as if it had not been removed; it, therefore, becomes necessary to lop off some part of the top of every tree when transplanted, that the remaining roots may be able to absorb abundant nourishment for these branches that we leave behind. If the plant is old, the proportion of roots that it loses by being transplanted is always greater than when it is young; but, in all cases, it is necessary to lop off some part of the top of the plant, otherwise there is great danger that it will then receive a check in its growth and become stunted; which is a disease that hardly admits of a cure but by amputation. To prevent this dangerous disease in a hedge, it is always proper to
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cut off the top of the quick entirely; which never fails to make it send out shoots the first year of a more than ordinary degree of vigour. This amputation ought always to be performed by a sharp tool, that the wound may be as clean as possible; and, when the hedge is to be planted on the face of a bank, it ought to be made about twelve inches above the root. Although this operation is not so indispensibly necessary on young plants as on those that are older; yet it is always of use, and ought never to be omitted.

Gardeners too often neglect this most necessary operation, and almost as universally prune the roots too much. If the plants have not been brought from a distance, or long kept out of the ground, it is only necessary to cut off the points of such roots as have been lacerated in taking up the plants; leaving as many small roots as possible, if they are sound. If, indeed, they have been too long exposed to the weather, so as to have some part of the smallest fibres killed, it will not be improper to cut away these dead fibres; but, it is in general the safest plan, to prune the roots but very little before planting.

§ XII.

Directions for the Manner of Planting.

The proper method of planting this kind of hedge is, first to turn up a little of the earth

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from the place where the ditch is to be made, and lay it upon the bank reversed; so as to form a bed for the plant about two inches thick above the solid ground. Upon this the thorns should be laid nearly in a horizontal direction, but enclining a little upward in the point, and having the ends of the stems just equal with the face of the bank, or projecting beyond it a very little, not more than half an inch; by which means, every plant will send out only one or two shoots, which will be the more vigorous as there are so few of them. But, if any of these plants should send out a greater number of shoots, it will be proper to prune away all these supernumeraries the first winter after planting; cutting them with a knife close by the stem from which they spring: For, it is the largeness of these original stamina of the hedge that will afterwards constitute its strength, and not the number of small ramifications, as is too generally imagined. But, if the shoots are numerous, they never do acquire such a degree of strength as when there are fewer of them.

The plants being thus regularly laid, should have their roots immediately covered with the best mold taken from the surface of the ditch; and the workmen should take care to keep that good mold well back upon the bank, and rather behind the roots, leaving the breast of the bank to be made up by the less fertile earth ta-

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ken from the bottom of the ditch. By this means the roots will have all the good earth about them; in which they will spread with freedom, and draw from it abundant nourishment; and the bad earth which forms the breast of the bank will produce much fewer weeds there, than the good earth would have done, if it had been kept near the surface. You will now likewise perceive the reason for cutting the plants at such a distance above the roots, (§ XI.) viz. that you may be thus allowed to put the roots among the good mold, and still leave room for a breast-work of bad earth of a sufficient thickness; whereas, if they had been cut shorter than is there mentioned, you would not only have been deprived of this conveniency, but would also have been obliged to plant the roots so near to the breast of the ditch, as to expose them very much to the droughts of summer, which would greatly retard their growth; for no plant delights more in a moderate degree of moisture than the white thorn; which is probably one reason why it thrives better in this method of planting than any other, and advances much faster in rainy seasons, or in wet climates, than in such as are drier. If the soil in which they are planted is poor, I would advise to mix some well made dung * with the earth that covers the roots of

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* I have met with many gentlemen who are firmly persuaded, that dung of every kind is hurtful to hedges,
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the thorns, which would greatly promote their growth, and be attended with very little expence; as the quantity necessary could be but very small *.

§ XIII.

and many other plants. It is much to be regretted, that mankind should adopt any kind of theory with so little reserve, as to shut their eyes against the plainest dictates of experience. I will not here attempt to undeceive those who may have adopted this opinion, by any kind of reasoning, which, in matters of this sort, is always in danger of being fallacious; but leave the decision of the matter to their own experience and observation; not doubting but that they will find, that, if there are any plants which are not forwarded in their growth, by the judicious application of dung to the soil in which they are reared, the number is extremely small, and that the hawthorn is not one of these.

* It will hardly be necessary here to remark, that the hedge ought to be carefully kept clear of weeds for several years; and that it ought likewise to be preserved from being broke down by cattle, by means of any kind of dead fence that may best suit the circumstance of the farmer to rear. A nobleman in Scotland, who is eminently distinguished by his attention to agriculture, and the many improvements that he hath made in that art, has lately contrived to effect both these purposes at once, by facing with stones the ditch in which the hedge is planted, making a small square hole for each thorn-plant, and cutting the stems of a sufficient length, so as to permit them to come quite through the dike; in which situation they advance as well as if no facing of stone had been there. In this way of planting, great care ought to be taken to reject bad plants, as it is more difficult to supply deficiencies afterwards than in the common way; large plants are here also more essentially necessary than in the ordinary mode of planting hedges.

§ XIII.

Directions for the Manner of Planting in a very exposed Situation.

Those who live in an open uncultivated country have many difficulties to encounter, which others who inhabit more warm and sheltered regions never experience; and, among these difficulties, may be reckoned that of hardly getting hedges to grow with facility. For, where a young hedge is much exposed to violent and continued gusts of wind, no art will ever make it rise with so much freedom, or grow with such luxuriance as it would do in a more sheltered situation, and favourable exposure.

But, although it is impossible to rear hedges, in this situation, to so much perfection as in the others, yet they may be reared even there with a little attention and pains, so as to become very fine fences.

If it is adviseable, in other cases, to plant the hedges upon the face of a bank, it becomes absolutely necessary in such an exposed situation as that I have now described: For the bank, by breaking the force of the wind, screens the young hedge from the violence of the blast, and allows it to advance, for some time, at first, with much greater luxuriance than it otherwise could have done.

But,

But, as it may be expected soon to grow as high as the bank, it behoves the provident husbandman to prepare for that event, and guard, with a wise forecast, against the inconvenience that may be expected to arise from that circumstance.

With this view, it will be proper for him, instead of making a single ditch, and planting one hedge, to raise a pretty high bank, with a ditch on each side of it, and a hedge on each face of the bank; in which situation, the bank will equally shelter each of the two hedges, while they are lower than it; and, when they at length become as high as the bank, the one hedge will in a manner afford shelter to the other, so as to enable them to advance with much greater luxuriance than either of them would have done singly.

To effectuate this still more perfectly, let a row of service-trees be planted along the top of the bank, at the distance of eighteen inches from each other, with a plant of eglantine between each two services. This plant will advance, in some degree, even in this exposed situation; and, by its numerous shoots, covered with large leaves, will effectually screen the hedge on each side of it, which, in its turn, will receive some support and shelter from them, so that they will be enabled to advance altogether, and form, in time, a close, strong, and beautiful fence.

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The *service* is a tree but little known in Scotland, although it is one of those that ought perhaps to be often cultivated there in preference to any other tree whatever, as it is more hardy, and, in an exposed situation, affords more shelter to other plants than almost any other tree I know: For it sends out a great many strong branches from the under part of the stem, which, in time, assume an upright direction, and continue to advance with vigour, and carry many leaves to the very bottom, almost as long as the tree exists; so that, if it is not pruned, it rises a large close bush, till it attains the height of a forest-tree.

It is of the same genus with the rawn-tree—and has a great resemblance to it both in flower and fruit; its branches are more waving and pliant—its leaves undivided—broad and round, somewhat resembling the elm, but white and mealy on the under side. It deserves to be better known than it is at present.

§ XIV.

Of the Use of the Eglantine in Fencing.

Although the hawthorn makes a very fine fence when planted alone; yet, it is rather improved, by having some plants of sweet-briar (*Eglantine*) intermixed with it. For, although this plant is so weak and straggling as never to make a fence strong enough by itself; yet, as
it

it advances with such prodigious rapidity, and is so entirely covered with prickles, it serves admirably well for intermixing with other stronger plants, for the purpose of thickening a hedge: And, as the plants can be reared at a very trifling expence, I think they may, on many occasions, be employed with great propriety.

If you employ nothing else than hawthorns, they should be planted about seven or eight inches a-part. But, your hedge will be more quickly reared, and at a more moderate expence, if they are planted at twelve inches a-part, with a plant of eglantine between every two thorns. But the eglantine should be planted out when very young; for, if the plants were large and strongly rooted, the shoots would be so luxuriant as to be in some danger of overtopping the thorns and choaking them. Plants of one year's growth, if vigorous, are of the proper size for this purpose; and these will require no lopping before they are planted.

§ XV.

Of the necessary Attention to the Hedge the first Year after Planting.

It will be necessary to examine the hedge with care, the first winter after planting; and, if there are any plants, either stunted or dead, they should be taken out, and their places be immediately

immediately supplied by others, more vigorous, if possible, than those that were planted the year before. For this purpose, every good husbandman should take care to reserve a few of the finest plants that he can pick out, and of the freest shooting kinds of thorn, (for there is a very great difference in this respect) which should be kept in the richest part of the nursery, and have the earth dug about them during the summer-season, with the greatest care, that their roots may be numerous and well formed. If he has taken this precaution, and is at pains to open the bank with a spade, so as to allow the roots to be properly placed, and lifts them from the nursery with due care, covering them immediately after planting with the richest earth that can be got, which ought to be further meliorated by a little well rotted dung, and cuts off the whole of the top at the time of planting; they will, in all probability, make such shoots next year as to be at once out of all danger of being choaked by the others. But, if this small degree of care had been neglected, or even deferred till another season, it would then have been too late, and the hedge must have remained for ever afterwards full of incurable gaps, that might have been effectually prevented by this well-timed attention.

§ XVI,

§ XVI.

Directions for Clipping and Pruning Hedges.

Nothing can be more prejudicial to a young hedge than an injudicious application of the scissars; and, although it be extremely common to clip the top of a hedge for a few years at first, even where it is to be discontinued ever afterwards; yet, it would hardly be possible to contrive a practice that would be more prejudicial to it than this is.

The chief properties that constitute the excellence of a hedge, are strength and closeness.—Now, a hedge can be made strong by nothing else than the vigour and size of the principal stems of which it is composed. But, it is evident, that, by cutting the tops of all the radical shoots, each of them is forced to send out a great many smaller ones, as in a pollard-tree; and each of these small stems being cut again and again, are divided into still smaller and more numerous ramifications, till the number of these are increased to such a degree, and their size, of consequence, so much diminished, that the hedge may be said to consist entirely of an infinite number of small twigs, closely interwoven with one another, which have not sufficient strength to make any considerable resistance to a furious bull, who will easily break through

through any part of such a hedge that he may chance to attack, however close it may appear to be. But if, instead of being cut in the top, the thorn be allowed to advance upwards without any interruption, its stem, like that of any other tree, will continue to encrease in size and strength, and, in a short time, become so large as to be able to resist the whole force of any animal that we may have occasion to fear. They even, in time, become so large as to occupy almost the whole space that was originally left between the plants, so as to form a solid vegetable wall (if I may use that expression) which it is almost impossible for any force to overturn. It is, therefore, obvious, that cutting the top of a hedge, when young, tends greatly to diminish the strength of it.

It will, perhaps, be a more difficult task to convince the reader, that this practice likewise tends to diminish the thickness of the hedge; although, I flatter myself, that I shall be able to demonstrate this as clearly as the other.

When the principal stem of any tree is cut over, the sap that would have gone to encrease the size of its top, being stopt in its ascent, forces out a great many shoots all round the stem, immediately below the place where it has been cut over. And, when this is the case with a hedge, the number of shoots that are crowded together draw the sap so powerfully to that place, and occasion such a deep shade below

low it, that all the horizontal shoots that had sprung out from the stem near the roots, being deprived of their nourishment, and the influences of the air, are checked in their growth, and in a short time totally perish; leaving the stem at the root quite naked and bare*. And,

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* As those who have not paid much attention to the growth of trees, may, perhaps, be at a loss to comprehend the full force of the argument made use of, I shall here subjoin a few observations tending to illustrate it more clearly.

The principal use of the branches of a tree, is, to pump up the sap from the roots, and distribute it properly through the whole plant; so that the health of the tree, and form of the trunk, in a great measure depend upon the proper arrangement of these. — Every branch carries off from the stem a part of the nourishment that is imbibed by the roots; and altho', in its passage, it serves to augment the size of that part of the stem that is below it, yet the parts that are above it receive no addition from the sap that is pumped up by this branch; so that, if some branches are allowed to remain upon the stem near the root, and others at regular distances above one another to the top, the under part of the stem will be of a considerable size, and it will taper gradually upwards, so as to stand extremely firm and secure. But, if all the branches are at once lopped away from the stem, and it is allowed to remain naked to a considerable height, it continues nearly of the same size from the root to the part where the branches begin to set out; and, being thus so long and slender, it is not of a sufficient strength to support the top, so as to be, in many cases, bent down towards the ground, and continue to grow in a distorted and languishing condition. This is more particularly observable in the broad-leaved Scots elm,

as there are, from that period, no branches springing immediately from the under part of the stem, to detain the sap in its passage, and make that part of it encrease in its size, it there continues small and weakly; while the top, continuing to advance with luxuriance, becomes so large and weighty as to be, with difficulty, supported by these small naked shanks, which gradually become barer and barer every year.

elm, and the freest shooting pear-trees, than in any other species of trees that I know: But the same phenomenon is observable in all trees, in a smaller or great degree, according to the vigour or pliability of their shoots.

But, as the sap always more naturally ascends in an upright than in a lateral direction, if, by any means, several strong shoots are made to spring from any part of the stem, these assume an upright direction, and continue to draw away a great deal of nourishment to themselves; so that the weaker horizontal shoots below them, not being able to attract to themselves a sufficient quantity of sap, they begin to languish, till at length, more and more weakened by the shade and dripping of the branches above them, they gradually fall away. Having thus, for a time, helped to encrease the size of the under part of the stem, so as to enable it properly to support its top, nature gradually frees herself from these useless branches; and, by their gradual decay, the stem is left of that delicate taper-form which is best adapted both for strength and beauty. This is the regular progress of nature, if left to herself. It ought to be the study of man to improve upon the hints that she affords him, and to direct her operations so as that they may best concur with him in promoting his design.

year. But every one knows, that, if the bottom of a hedge is open, it is of very little consequence whether it be close above or not: And, I leave it to be determined by experience, whether this is not, in general, the condition of hedges which have been clipped in the top when young; especially in those cases where the hedge has made vigorous shoots the first year. And, if it shall be found, that this is, in general, the case, we must conclude, that this practice tends to make the hedge thinner, as well as weaker than it would have been, if it had been entirely omitted.

But, if an hedge is allowed to advance in height, without being cut in the top, the small branches that spring out near the root, not being starved by the extraordinary suction, or suffocated by the shade of too luxuriant branches above them, continue to live, and detain a part of the sap; so as to make the under part of the stem still continue to encrease in size and strength, and be well able to support the small top that it thus acquires. And, if the most luxuriant side-branches that may spring out above, are, from time to time, pruned away, so as not to be allowed to overshade those that may be below; these last will continue to grow as long as the hedge exists. And as, by this management, there will be but few side-branches of any considerable size, the principal stems will advance with very great vigour, gradually tapering from the root upwards.

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I cannot be too particular in advising the husbandman to bestow almost his whole attention to the proper formation of the upright stems of the hedge: Because, upon this, the whole future strength of the hedge must entirely depend. And, if these are once rightly formed, it will be an easy matter to give it every quality that we could wish for in a hedge. For, if these strong stems should even be entirely destitute of small branches, they may be made to push out abundance of them whenever it may be thought necessary, only by making a slight wound in the naked stem, where-ever you desire that young branches should appear: For, below every such wound, a number of small shoots will spring forth the ensuing season; the points of which being cut off, will send out a still greater number of small twigs, which, by being frequently cut, will, in a short time, form a covering as close as could be desired.

The truth of this reasoning I myself experienced at a very early period of my life; for, having then had occasion to dress a garden that was surrounded by an old hedge, which had always been allowed to grow as nature prompted; never, that I know of, having been touched either by knife or scissars, I found the branches straggling very far on every side, all of which I caused to be cut off quite close by the upright stems, which then were left entirely

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ly naked, and appeared like as many may-poles placed beside one another. But, by cutting a good many slight notches all along these stems, at the distance of a few inches from one another, they were, in one year, entirely covered with young shoots; which, by being cut once or twice in one season, put out such a number of smaller ramifications, as in a short time formed a covering so very close, that it was hardly possible to see any object through it at any part. Nor did I ever, in my life, see a hedge, that, either for strength or beauty, could be compared with this one. Many of the stems being six or eight inches in diameter; and they grew so close to one another, that no animal larger than a small bird could possibly have penetrated it.

From these observations, I hope, it will appear evident, that, if we wish to have a right hedge, either for strength or closeness, it is of importance never to shorten the top-shoots; at least, while it is young. But, it is always of use to prune the sides; cutting off all the lateral shoots, with the scissars, quite close to the upright stems, after the first year's growth. And if, after the growth of the second year, it should so happen, that too many shoots have sprung out at the top of the first year's shoots, (which very frequently is the case,) these super-numeraries should be cautiously pruned away with a knife; taking out all the strong upright
growing

growing branches, excepting one for a stem; being always particularly careful to cut them away quite close to the stem from which they spring: For, if this caution were neglected, a greater number of shoots would spring out from the wound, and the malady be increased rather than diminished.

If these circumstances are attended to, the hedge will need no other care ever afterwards; but to be defended from cattle, kept free of weeds, and clipped in the sides once a-year for some time; being always careful, at each clipping, to go as close to the last as can be easily done. But, in a particular manner, be attentive, the first time you perform this operation, to clip it as near to the upright stems as possible: For, as these side-branches must always extend a little farther at every cutting, if this caution is not observed, these lateral shanks will, in time, become naked; and the interval between the ribs, (as the upright shoots may properly be called,) and the reticular tegument (or skin) that covers the surface, would be too great, and form a very disagreeable void.

If these rules are observed for a few years, the hedge, while it advances in height, will become as close in the sides as could be wished for. And, although the clipping of the sides should be discontinued after a few years, it will be in no danger of running into great disorder; for, as the vigour of the side-shoots will have been

much diminished by having been so frequently divided, none of them will afterwards advance to such a distance as to deform or hurt the hedge; so that this operation may be discontinued, unless where very great neatness is required.

§ XVII.

How to recover a Hedge after it has been stunted in its Growth.

But if, from the poorness of the soil in which your hedge is planted, or from any other cause, it should so happen, that, after a few years, the hedge becomes sickly, and the plants turn poor and stunted in appearance, the easiest and only effectual remedy for that disease, is to cut the stems of the plants clean over, at the height of an inch or two above the ground; after which they will send forth much stronger shoots than they ever would have done without this operation. And, if the hedge be kept free of weeds, and trained afterwards in the manner above described, it will, in almost every case, be recovered, and rendered fresh and vigorous.

This amputation ought to be performed in autumn, or the beginning of winter; and, in the spring, when the young buds begin to show themselves, the stumps ought to be examined with care, and all the buds be rubbed off,

off, excepting one or two of the strongest and best placed, which should be left for a stem. For, if the numerous buds that spring forth round the stem are allowed to spring up undisturbed, they will become, in a few years, as weak and stunted as before; and the hedge will never afterwards be able to attain any considerable height, strength, or healthfulness. — I have seen many hedges that have been repeatedly cut over, totally ruined, by not having attended to this circumstance in proper time.

If the ground, for sixteen or twenty feet on each side of the hedge, be fallowed at the time that this operation is performed, and get a thorough dressing with rich manures, and be kept in high order for some years afterwards, by good culture and meliorating crops, the hedge will prosper much better than if this had been omitted, especially if it has been planted on the level ground, or on the bank of a shallow ditch.

§ XVIII.

Of recovering old open Hedges by Plashing.

It sometimes happens, that a hedge may have been long neglected, and be, in general, in a healthy state, but full of gaps and openings, or so thin and straggling, as to form a very imperfect sort of fence. On these occasions, it is in vain to hope to fill up the gaps by

planting young quicks; for these would always be outgrown, choaked, and starved by the old plants: Nor could it be recovered by cutting clear over by the roots; as the gaps would still continue where they formerly were. The only methods that I know of rendering this a fence are, either to mend up the gaps with dead wood, or to *plash* the hedge: Which last operation is always the most eligible, where the gaps are not too large to admit of being cured by this means.

The operation I here call plashing, may be defined, '*a wattling made of living wood.*' To form this, some stems are first selected, to be left as stakes, at proper distances, the tops of which are all cut over at the height of four feet from the root. The straggling side-branches of the other part of the hedge are also lopped away. Several of the remaining plants are then cut over, close by the ground, at convenient distances; and the remaining plants are cut, perhaps half through, so as to permit them to be bent to one side. They are then bent down almost to a horizontal position, and interwoven with the upright stakes, so as to retain them in that position. Care ought to be taken, that these be laid very low, at those places where there were formerly gaps; which ought to be farther strengthened by some deadstakes, or truncheons of willows, which will frequently take root in this case, and continue to live,

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And sometimes a plant of Eglantine will be able to overcome the difficulties it there meets with, strike root, and grow up so as to strengthen the hedge in a most effectual manner.

The operator begins at one end of the field, and proceeds regularly forward, bending all the stems in one direction, so as that the points rise above the roots of the others, till the whole wattling is compleated to the same height as the uprights; after which it assumes an appearance somewhat resembling that which is represented in Fig. 5.

An expert operator will perform this work with much greater expedition, than one who has not seen it done could easily imagine. And, as all the diagonal wattlings continue to live, and send out shoots from many parts of their stems, and, as the upright shoots that rise from the stumps of those plants that have been cut over, quickly rush up through the whole hedge, these serve to unite the whole into one entire mass, that forms a strong, durable, and beautiful fence.

This is the best method of recovering an old neglected hedge, that hath as yet come to my knowledge.

§ XIX.

Directions for preventing the young Twigs of a Hedge from being killed in Winter.

In some cases, it happens that the young shoots of a hedge are killed every winter; in which

which case, it soon becomes dead and unsightly, and can never rise to any considerable height. A remedy for this disease may therefore be wished for.

Young hedges are observed to be chiefly affected with this disorder; and it is almost always occasioned by an injudicious management of the hedge, by means of which it has been forced to send out too great a number of shoots in summer, that are thus rendered so small and weakly, as to be unable to resist the severe weather in winter.

It often happens that the owner of a young hedge, with a view to render it very thick and close, cuts it over with the shears a few inches above the ground, the first winter after planting; in consequence of which many small shoots spring out from each of the stems that has been cut over:—Each of which being afterwards cut over in the same manner, sends forth a still greater number of shoots, which are smaller and smaller, in proportion to their number.

If the soil in which the hedge has been planted is poor, in consequence of this management, the branches, after a few years, become so numerous, that the hedge is unable to send out any shoots at all, and the utmost exertion of the vegetative powers enables it only to put forth leaves. These leaves are renewed in a sickly state for some years, and, at last, cease to grow at all—the branches become covered with fog, and the hedge perishes entirely.

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But, if the soil be very rich, notwithstanding this great multiplication of the stems, the roots will still have sufficient vigour to force out a great many small shoots, which advance to a great length, but never attain a proportional thickness. And, as the vigour of the hedge makes them continue to vegetate very late in autumn, the frosts come on before the tops of these dangling shoots have attained any degree of woody firmness; so that they are killed almost entirely by it; the whole hedge becomes covered with these long dead shoots, which are always disagreeable to look at, and usually indicate the approaching end of the hedge.

The causes of the disorder being thus explained, it will readily occur, that the only radical cure is amputation; which, by giving an opportunity to begin with training the hedge anew, gives us also an opportunity of avoiding the errors that occasioned it. In this case, care ought to be taken to cut the plants as close to the ground as possible, as there the stems will be less numerous than at any greater height. And particular attention ought to be had to allow very few shoots to arise from the stems that have been cut over, and to guard carefully against shortening them.

But, as the roots, in the case here supposed, will be very strong, the shoots that are allowed to spring from the stems will be very vigorous, and there will be some danger of their continuing

ing to grow later in the season than they ought in safety to do; in which case, some part of the top of the shoot may perhaps be killed the first winter, which ought, if possible, to be prevented. This can only be effectually done, by giving a check to the vegetation in autumn, so as to allow the young shoots to harden in the points before the winter approaches. If any of the leaves or branches of a tree are cut away, while it is in the state of vegetation, the whole plant feels the loss, and it suffers a temporary check in its growth, in proportion to the loss that it thus sustains. To check, therefore, the vigorous vegetation at the end of autumn, it will be prudent to chuse the beginning of September for the time of lopping off all the supernumerary branches from the young hedge, and for clipping off the side-branches that have sprung out from it; which will, in general, be sufficient to give it such a check in its growth at that season, as will prevent any of the shoots from advancing afterwards. If the hedge is extremely vigorous, a few buds may be allowed to grow upon the large stumps in the spring, with a view to be cut off at this season, which will tend to stop the vegetation of the hedge still more effectually.

By this mode of management, the hedge may be preserved entire through the first winter. And, as the shoots become less vigorous every successive season, there will be less difficulty

culty in preserving them at any future period. It will always be proper, however, to trim the sides of a very vigorous hedge for some years, while it is young, about the same season of the year, which will tend powerfully to prevent this malady. But, when the hedge has advanced to any considerable height, it will be equally proper to clip it during any of the winter-months, before Candlemas.

It deserves to be remarked, before we leave this article, that the disease here complained of is seldom dangerous, but in situations that are pretty much exposed.—And there are some situations so very much exposed to boisterous winds, that no care in training the hedge will be sufficient to preserve it. In these cases, the hedges must be protected from the violence of the blasts, by the means prescribed § XIII. which, united with the management here recommended, will seldom fail to prove efficacious.

§ XX.

Of Lopping full grown Hedges.

If you live in a country where fuel is not scarce, I would advise never to cut the top of the hedge at all, but rather allow it to advance upwards in all the beautiful luxuriance of nature; by which means it will not only afford a much better shelter to the fields, but will also,

also, in time, come to be annually covered with beautiful tufts of blossom, which diffuse an agreeable aromatic odour to a considerable distance around, and are succeeded by large clusters of berries that are very agreeable to the eye; so that it becomes, in this state, one of the finest ornamental shrubs that this climate produces.

But, if strong necessity compels you to cut your hedge, for the sake of billets, at any rate, allow it to have attained a considerable degree of strength before you think of cutting it for the first time, and then cut the tops clean over, at the height of four or five feet from the ground; which operation may be repeated afterwards, as often as shall be found necessary; taking care, after each cutting, to lop off all the luxuriant side-branches that may chance to spring out in consequence of that operation, which might be in danger of hurting the side-shoots that may be below.

In this way, you may have a very good hedge; but, it will neither afford such shelter to your field, nor be so beautiful, as if it had never been touched at all at the top.

§ XXI.

Of Ornamental Plants in Hedging.

Although ornament ought only to be considered as a secondary object by the farmer; yet, where it can be united with the useful, it need not be wholly disregarded. The country is, perhaps,

perhaps, the best field for allowing the sympathetic affections of the mind to be exerted with the most unbounded freedom, which forms the basis of that desire for universal harmony, that constitutes a true and correct taste; which is, perhaps, the best preservative that the mind can ever meet with, against every low and sordid affection. Let not, then, the man, who wishes to be extensively useful to his country, to his family, and, of consequence, to himself, close his eyes upon the beauties of nature; but rather allow them to shed their benign influences on his spirit. It will serve to shorten his labour and sweeten his toil; will help to brighten those gloomy intervals that the mind, which is totally occupied with sordid views, must frequently experience, and be a source of content and cheerfulness, which must ever constitute one principal ingredient of rural and domestic felicity.

If, then, you do not despise ornament entirely, or disregard the beauties of nature, you may render your hedges very beautiful, without any additional expense, by intermixing a few plants of *pyracantha* with your thorns when you plant them. The *pyracantha* (evergreen thorn) is one of the most beautiful evergreens that we have in this country; but, as it is a weakly plant, unable to support itself, it has, in general, been but little attended to. If a slip of this were planted between every second or third thorn, it would, in a short time, spread so far on every side, as to meet; and,
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being supported by the hawthorn, would rise to the top of the hedge, and render the whole as beautiful as if it were composed of this plant alone. And, as its large clusters of scarlet berries hang upon it during the greatest part of the winter-season, by it, the hedge would be made not only closer and warmer during the winter, but also, more pleasing to the eye than it otherwise would have been. This plant is not an exceeding quick grower, but it is by no means difficult to rear; every twig of it, if struck into a good soil, taking root as readily as a willow. As I have planted it in this manner among my own hedges, and find it answer the intended purpose, I can recommend it with the greater freedom.

If you are desirous of rendering your hedges still more agreeable, it may be easily done, by planting, through them, a few twigs of different kinds of honeysuckles (woodbine); or intermixing with them a few of the most hardy and freest shooting kinds of roses, which will grow without any extraordinary degree of attention or care. It will be best, however, not to plant the honeysuckles till the hedge is two or three years old; as some kinds of these grow so very fast as might put the hedge in some danger of being choaked by them, if they were planted at the same time with it. A few plants of the crab-tree, intermixed with the white-thorn, form also a most agreeable variety, as
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the beautiful blush-coloured blossom of that plant, so early in summer, is extremely delightful.

I might here enumerate several other shrubs that could, with propriety, be employed for adorning hedges; but, as this is, in some measure, foreign to the design of this essay, which is chiefly calculated to convey useful instruction, more than the foregoing hints on this head, might justly be deemed superfluous.

§ XXII.

Of the Use of the Willow in Fencing.

Although the white-thorn be, in general, the most proper plant for making fences, yet, there are several others that may be successfully employed on some occasions; which, for some particular purposes, may be even preferable to it. Among these, you will perhaps be surprised to hear me mention the willow; yet, I have found that it may be employed, in some cases, with very great advantage, by a particular method of training it, not generally known, which I shall now endeavour to describe.

It is, in general, imagined, that the willow can be made to thrive no where except in wet or boggy ground; but this is one of those vulgar errors, founded upon inaccurate observation, too often to be met with on subjects relating to rural affairs. For, experience has sufficiently

ciently convinced me, that this plant will not only grow, but thrive, in any rich well cultivated soil, (unless in particular circumstances that need not here be mentioned), even although it be of a very dry nature *. It could

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* To remove, in some measure, the prejudice that might, perhaps, arise in the mind of inattentive observers against the writer, for the seemingly paradoxical assertion in the text, it will not be improper here, to mention a few facts relating to this subject, that their own future experience and observation will enable them to judge of impartially.

Water is not more essentially necessary to the thriving of the willow than to most other plants or trees; but only is, on many occasions, incidentally useful, as tending to promote that particular tenderness, and easy penetrability of soil, which is essentially necessary to the health, if not to the very existence of this species of plants. As a proof of this, recollect, if ever you saw any kind of willow thrive in what can properly be called a quagmire, where the soil is swelled up with such a superabundance of water, as to be reduced to a sort of semi-fluid state. Again, Did you ever see willows thrive, if planted upon a hard, poor, clayey soil, however much the surface may be covered with water? I foolishly, in my younger years, planted several pieces of ground of this nature with willows, but without any sort of success. Again, although it is rare to meet with a sandy soil that is so much subjected to wetness, as to be never dry through a whole season, yet I once met with a case of that kind; the situation being so low, that, notwithstanding the best drains that could be made from it, the ditches were never dry. Willows were planted upon the face of the ditch, so as never to be above six inches from the water; but the greatest shoots that ever they made in

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not, however, in general, be made to thrive, if planted in the same manner as thorns;—nor, would

one season, did not exceed six inches. If your observations shall concur with mine in these examples, we will be obliged to conclude, that wetness does not, in all cases, cause willows to prosper.

On the other hand, please again to recollect, if ever you saw willows planted in a rich mellow garden-mold (if the soil was not a hard sand or gravel), which did not send out luxuriant shoots, whether the situation was dry or otherwise? I am disposed to think that you have not. For, altho' I have tried the experiment several times, it has never once failed with me. And, I have frequently had shoots of willows from eight to nine feet in length, in one season, upon soils naturally as dry as almost any could be.—In short, the results of all my observations, relating to the growth of willows, are, That they will thrive only i such soils as are of a soft light nature, which are easily penetrated by the roots of this plant:—That unmellowed clays are too coherent for them; and that sand, by falling too closely together, makes too much resistance to the roots.—That rich garden-mold, if kept open by frequent digging, is always in a proper state for them:—That banks of mellow earth, by the sides of rivulets or running-water, which often rises near the surface of them, by being kept always soft by the natural moisture, without being drowned or rendered poachy by the adhesiveness of the soil, are peculiarly proper for rearing this plant:—That even clayey soils, or such as tend towards clay, if not absolutely pure and rigid, when lying so low as to be within the reach of water, if thrown up into narrow banks or ridges by the spade, having ditches between each, always, or for the greatest part of the year, filled with water, will, by this management, be rendered very proper for rearing this plant. Because, in this situation, the ridge, being above the level of the water, is exposed to the meliorating influences

would it, in any respect, be proper to train it up for a fence, in the same way as has been described, as best for that plant. The willow, as a fence, could seldom be successfully employed, but for dividing into separate inclosures any extensive field of rich ground. And, as it is always necessary to put the soil into as good order as possible before a hedge of this kind is planted in it, the easiest method of putting it into the necessary high tilth, will be to mark off the boundaries of your several fields in the winter, or early in the spring, with a design to give a complete fallow to a narrow ridge, six or eight feet broad, in the middle of which the hedge is intended to be planted the ensuing winter. This ridge ought to be frequently ploughed during the summer-season, and, in autumn, be well manured with dung, or lime, or both, (for it cannot be made too rich) and be neatly formed into a ridge before winter.

Having prepared the ground in this manner, it will be in readiness to receive the hedge, which ought to be planted as early in winter as can be got conveniently done; as the willow is as much hurt by being planted late in the spring, as the hawthorn, (§ X.) But, before you begin

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fluences of the sun and air, and being constantly kept moderately damp by the suction of the roots of the plants that grow upon it, the mold quickly acquires that mellow richness so necessary for the well-being of the willow. Whether these observations are just or not, future experience and observation will determine.

to make a fence of this kind, it will be necessary to provide a sufficient number of plants; which will be best done by previously rearing them in a nursery of your own, as near the field to be inclosed as you can conveniently have it. For, as they are very bulky, the carriage of them would be troublesome, if they were brought from any considerable distance. The best kinds of willow for this use, are such as make the longest and strongest shoots, and are not of a brittle nature. All the large kinds of hoop-willows may be employed for this purpose; but, there is another kind, with stronger and more taper shoots, covered with a dark green bark when young, which, upon the older shoots, becomes of an ash-gray, of a firm texture, and a little rough to the touch. The leaves are not so long, and a great deal broader than those of the common hoop-willow, pretty thick, and of a dark green colour. What name this species of willow is usually known by, I cannot tell; but, as it becomes very quickly of a large size at the root, and is strong and firm, it ought to be made choice of for this purpose, in preference to all other kinds that I have seen.

The shoots ought to be of two or three years growth before they can be properly used, and should never be less than eight or nine feet in length. These ought to be cut over close by the ground immediately before planting, and carried to the field at their whole length.

The planter having stretched a line along the middle of the ridge which was prepared for their reception, begins at one end thereof, thrusting a row of these plants firmly into the ground, close by the side of the line, at the distance of eighteen or twenty inches from one another; making them all slant a little to one side in a direction parallel to the line. This being finished, let him begin at the opposite end of the line, and plant another row in the intervals between the plants of the former row; making these incline as much as the others, but in a direction exactly contrary; and then plaiting these basket-ways, work them into lozenges like a net, fastening the tops by plaiting the small twigs with one another, which, with very little trouble, may be made to bind together very firmly. The whole, when finished, assumes a very beautiful net-like appearance, as is represented at fig. 5th; and is at first a tolerable good defence: And, as these plants immediately take root and quickly increase in size, it becomes, after a few years, a very strong fence, which nothing can penetrate.

This kind of hedge I myself have employed, and find that a man may plant and twist properly about a hundred yards in a day, if the plants be laid down to his hand: And, in a situation such as I have described, I know no kind of fence which could be reared at such a small expense,—so quickly become a defence, and
continue

continue so long in good order. But it will be greatly improved by putting a plant of eglantine between each two plants of willow, which will quickly climb up and be supported by them; and, by its numerous prickles, would effectually preserve the defenceless willow from being browsed upon by cattle.

As it will be necessary to keep the narrow ridge, upon which the hedge is planted, in culture for one year at least, that the plants of eglantine may not be choaked by weeds, and the roots of the willow may be allowed to spread with the greater ease in the tender mold produced by this means, it will be proper to stir the earth once or twice by a gentle horse-hoe in the beginning of summer; and, in the month of June, it may be sowed with turnips, or planted with coleworts, which will abundantly repay the expence of the fallow.

§ XXIII.

Of the Use of the Lombardy Poplar in Fencing.

The Lombardy poplar may likewise, on some occasions, be employed for a fence with propriety. This is a tree that has been lately introduced into Britain from Germany, and is not yet so generally known as it seems to deserve. It is said to be one of the quickest growing trees that is found in northern climates; and the

wood is said to be of as great value to the husbandman as either ash or elm. It is easily propagated, by cuttings like the willow, and, like it, delights in a rich mellow soil, tending a little toward dampness, in which it grows with amazing vigour; rising with a strong upright stem, growing three or four feet in height each year for some time, while it is young, and in its most vigorous state.

But, although it may be easily propagated by cuttings, yet it is always adviseable to plant these first in a nursery of rich garden-mold, where they may be allowed to take root, and acquire a little strength before they are planted out, where they are to remain in a hedge: For, as some of these usually do not strike root so readily as others, it would occasion some irregularity in the growth of the hedge, that may be avoided by this precaution. After they have been nursed a year or two, and have formed good roots, they may be taken up and planted on a bank in the same manner as thorns, managing them in every respect as the thorns (§ XII. XIII. XIV.); only observing to put a plant of eglantine for every plant of poplar for the whole length of the hedge. And, as this tree would, in all probability, (for I here speak only from analogy, never having seen them planted in this way,) make very strong shoots, they would soon be large enough to form a very strong fence; and the eglantine would furnish
the

the defensive prickles which this plant stands so much in need of. But, the way in which I apprehend that this plant might be most advantageously employed in fencing, would be as follows.

Let the young plants remain in the nursery till they are become as large at the root as the wrist of an ordinary man, which may be expected to be the case in four or five years from the time of planting; taking care to dig the earth each year between the rows, that the plants may have abundance of short well formed roots. When the plants are of a proper size, prepare a ridge to receive them, exactly in the same manner as was directed for the willows (§ XXII.) and, having first cut off all their tops at the height of four or five feet from the ground, raise them from the nursery with as great caution as you can,—carry them directly to the ridge, and plant a row of these in the middle of it, in an upright position, at the distance of one foot from one another; which will form a sort of railing, as is represented at Fig. 7th; always taking care to put a plant of eglantine between every two poplars, for the reasons already mentioned. And to keep them more firmly together, and in some measure to prevent cattle from attempting so readily to rush through between them at first, it will be of use to twist some shoots of willows along their top, as is represented in the figure; or, in places
where

where these cannot be had, a strong rope of straw twisted may be employed as a *succedaneum* for it.

These trees would not fail to send out strong shoots from the top of every stem, as at E. which would quickly arrive at a considerable magnitude; and the root-stems increasing in size proportionally, would in time close the intervals so much, as that no animal whatever could break through it. The tops of these trees might be afterwards cut over at the height of five feet from the ground, whenever the shoots had attained the magnitude that should be thought the most proper for the purpose that they might be designed for; whether it was walking-staffs, hurdles, hop-poles, shafts to carts, or any other use that the peculiarities of the situation might render most advantageous; and would thus, in all probability, afford a profit to the farmer much greater than could be drawn from any other kind of fence whatever. Reader, observe, I do not speak from experience. What I here hint is only probable conjecture; let it, therefore, make no further impression on your mind than reason seems to authorise*.

§ XXIV.

* Since writing the above, I have met with some facts that seem to show, that the Lombardy poplar is not such an exceeding quick grower, or valuable tree in other respects as we were made to believe when it was first introduced into Great Britain. But, as several kinds of strong upright

§ XXIV.

Of the Use of the Quick-beam, or Rawn-tree, in Fencing.

Another plant that may be employed for the same purposes, and in the same manner as the last mentioned, is the wild service, sometimes called the mountain-ash, or raw-tree. This is one of the quickest growing trees, for a dry barren soil, that is known in this country. It grows upright, and tapers gradually from the root—is extremely firm in the stem, and is hurt by no sort of exposure. At this present time, I have some plants of it growing upon a very indifferent soil, which, in eight years from the time of sowing the seeds, are about twelve feet in height, and eight or nine inches in girth at the root; so that, I think, there is but little doubt, but that these trees might be employed for a fence in the same manner as was described for the poplars, upon such poor and barren soils as would be improper for them. This tree ought to be raised from seeds, in the same manner as the hawthorn;—transplanted from the seed-bed at one or two year's growth into a rich garden-mold

upright shooting willows might be employed as a fence in this way, as well as the elm, hornbeam, &c. I chuse to let the passage remain without further correction.

mold, and, in four or five years, they would be fit for planting out upright.

§ XXV.

Of the Use of the Alder in Fencing.

The alder might be employed for the same purpose upon damp soils. If propagated from seeds, it rises upright, and grows very fast; and, being strong in its shoots, would be well adapted for this use.

Hedges are undoubtedly the best fences; and would, on almost all occasions, be preferable to those of every other kind, were they not so long of coming to perfection after they are planted, and so difficult to be preserved from other accidents during that period; so that it has hitherto been a *desideratum* in agriculture, to find out something that should be an immediate fence as a wall, and lasting as a hedge. Whether the four plants last mentioned will effectuate this purpose in the manner above proposed, I will not take upon me to say; but, as the matter is of considerable importance, and there seems to be a probability that they may at least be of *some* use, I hope I shall be excused for having hazarded a few conjectures upon this head.

§ XXVI.

§ XXVI.

Of Furze, or Whins, as a Fence.

Whins (furze) have been often employed as a fence when sowed upon the top of a bank. They are attended with the convenience of coming very quickly to their perfection, and of growing upon a soil in which few other plants could be made to thrive: But, in the way that they are commonly employed, they are neither a strong nor lasting fence.

The first of these defects may, in some measure, be removed, by making the bank upon which they are sowed (for they never should be transplanted) of a very considerable breadth; in order that the largeness of the aggregate body, considered as one mass, may, in some measure, make up for the want of strength in each individual plant.

With this view, a bank may be raised of five or six feet in breadth at the top, with a large ditch on each side of it; raising the bank as high as the earth taken from the ditches will permit; the surface of which should be sowed pretty thick with whin-seeds. These will come up very quickly; and, in two or three years, will form a barrier that few animals will attempt to break through, and will continue in that state of perfection for some years.

The

The greatest objection to this plant as a fence is, that, as it advances in size, the old prickles always die away; there being never more of these alive at any time upon the plant, than those that have been the produce of the year immediately preceding; and these thus gradually falling away, leave the stems naked below as they advance in height; so that it very soon becomes an exceeding poor and unsightly fence; the stems being entirely bare, and so slender withal, as not to be able to make a sufficient resistance to almost any animal whatever. To remedy this great defect, either of the two following methods may be adopted that shall best suit your situation and circumstances.

The first is, to take care to keep the banks always stored with young plants; never allowing them to grow to such a height as to become bare below. And, it was principally to admit of this, without losing at any time the use of the fence, that I have advised the bank to be made up of such an unusual breadth. For, if one side of the hedge be cut down quite close to the bank, when it is only two or three years old, the other half will remain as a fence till that side become strong again; and then the opposite side may be cut down in its turn; and so on alternately as long as you may incline: By which means the bank will always have a strong hedge upon it, without ever becoming naked at the root. And, as this plant, when
bruised,

bruised, is one of the most valuable kinds of winter food yet known for all kinds of domestic animals *, the young tops may be carried home and employed for that purpose by the farmer; which will abundantly compensate for the trouble of cutting, and the waste of ground that is occasioned by the breadth of the bank.

The other method of preserving a hedge of whins from turning open below, can only be practised where sheep are kept; but may be there employed with great propriety. In this case, it will be proper to sow the seeds upon a sharp ridge of earth, shovelled up from the surface of the ground on each side, without any ditches. If this is preserved from the sheep for two or three years at first, they may then be allowed to have free access to it; and, as they can get up close to the foot of the bank upon each side, if they have been accustomed to this kind of food, they will eat up all the young shoots that are within their reach, which will occasion them to send out a great many lateral shoots; and these being continually browsed upon, soon become as close as could be desired, and are then in no sort of danger of becoming naked at the root, although the middle part should advance to a considerable height.

The

* Some may perhaps imagine, that the expression in the text is rather too bold; but, I have very sufficient reason, from undoubted experience, for using it.

The reader ought to be apprised of one very great objection to this kind of fence, viz. that the seeds are blown by the wind into the fields, and come up in such abundance, as to become a very great nuisance. As it is hardly possible to extirpate them when they are once established, every one, therefore, ought duly to consider what are to be the consequences, before he sows them.

§ XXVII.

A particular Kind of Fence described for Orchards, Bleaching Greens, &c.

The fences hitherto mentioned are only intended to preserve fields from the intrusion of cattle. But, on some occasions, it is necessary to have a fence that would even resist the efforts of men to break through it; as around bleaching fields, orchards, &c.; the want of which often subjects the proprietor of such fields to very disagreeable accidents. And, as such a fence might, on some occasions, be procured at no great expence or trouble, it were to be wished that the method of doing this were more generally known.

To effectuate this, it is necessary to begin by trenching up, or ploughing a large belt all around the field you mean to inclose, of forty or fifty feet or more in breadth, if you find it convenient; the outer edge of which should be
fenced

fenced by a good dike, or a ditch and hedge. This belt should be kept in culture one year at least, and well manured, if your situation will admit of it; and laid up before winter, in such a manner that no water may be suffered to lodge upon it; and planted, in the winter time, all over with plants of eglantine, so thick as not to be above two feet from one another. Between these, put a good number of young birch plants not above two years old, interspersed with hazels, oak, ash, rowan, (wild service,) and other trees that you think will thrive upon your soil; together with thorns, hollies, brambles, and woodbine (honey-suckle); and having then fenced it from cattle, keep down the weeds that may rise upon its surface, as long as it is conveniently accessible; leaving it afterwards to nature.

If this is done, and your soil be not extremely bad, the belt, in a very few years, will be entirely filled with a close bush of trees, so intermixed with the bending branches of the eglantine, and bound together by the trailing shoots of the bramble and woodbine, that no animal above the size of a cat could penetrate; especially when it is of such a depth as I have recommended.

The first hint I got for a fence of this kind, was from a small thicket of brush-wood that I had planted for ornament, pretty much in the manner above described; which, in a short time,

time, became so much interwoven with the sweet briar, that it was impossible to find any access into it.

But, as all kinds of trees and shrubs, if planted very close upon one another, become naked at the root when they arrive at any considerable size, care should be taken to prevent it from ever coming to that state, by cutting it down whenever it is in danger of being open at the root.

And, as it would be improper ever to leave the field entirely defenceless, it is a great advantage to have the belt as broad as it conveniently may be, so that the one half of it may be a sufficient fence; by which means, we will have it in our power to cut down the inside and the outside of this belt alternately, so as still to keep the thicket young, and never to want, at any time, a sufficient fence. The brush-wood that this would afford at each cutting, would, in almost every situation, yield such a revenue as might do much more than indemnify the proprietor for the rent of the ground that was occupied by the fence. And, if the field was in such a situation as required shelter, some trees might be allowed to grow to their full size about the middle, without any inconvenience, if the belt were of a sufficient breadth.

§ XXVIII.

§ XXVIII.

Of securing the Banks of Rivers, so as to prevent the Earth from being washed away by the Violence of the Stream.

There is yet another species of fencing, as useful as any of these already mentioned, which is in general much less understood, and more difficult to execute properly, that deserves here to be taken notice of; viz. the method of securing the banks of rivers from being washed away by the violence of the stream, and of preventing the damages that may otherwise be occasioned by the swelling of the waters.

It frequently happens that, when a river runs in a bed of rich vegetable mold, the least accident that may chance to divert the stream towards any particular part of the bank, causes it to sweep away large tracts of fine ground, to the very great detriment of the proprietor, as well as the public; as this fine mold is usually carried to the sea, and the place that the water leaves to occupy the new bed that it thus forms for itself, is generally of a much worse quality, consisting chiefly of stones, sand, and gravel.

In some cases, where the whole force of the current is quite close to the bank, and the materials necessary for fencing it are not to be found, it may perhaps be impossible, or very difficult,

difficult, totally to prevent this evil; but, for the most part, it admits of a cure that can be obtained at a pretty moderate expense.

If you carefully observe the banks of rivers, you will readily remark, that these ravages are always most considerable at those places where the bank rises perpendicularly to a pretty considerable height above the ordinary surface of the water, and never at those places where the banks shelve down gradually towards the water's edge. For, when the river is swelled to a great height by rains, and runs with a force and rapidity greater than usual, it strikes violently against these perpendicular banks that directly oppose its course; and, as these are composed of earth quite bare and uncovered, they are easily softened by the water, and quickly washed away; so that the upper part of the bank being thus undermined, falls by its own weight into the river, and is carried off in prodigious quantities. But, when the river rises to any considerable height, it gently glides along the surface of those parts of the bank that shelve gradually downwards to the water's edge; which, being defended by the matted roots of the grass with which it is covered, scarcely sustains any damage at all; and is nearly the same after the water has retired within its banks as before the inundation.

These are facts which no one who has bestowed the least attention to this subject can fail

fail to have observed; and they clearly point out, that the first and most necessary step towards a cure, is, to level down the edge of the bank that is next the water, so as to make it slope gradually down towards the river.

If the bank is very high, and you have no other particular use for the earth that must be taken from it, the easiest method of disposing of it, will be to throw it into the river. But, in whatever manner you dispose of the earth, the slope of the bank must be continued until the inner edge of it is as low as the surface of the water at the driest time of the year, and be made to ascend gradually upwards from the water with an easy slope, till it comes to the level of the ground, or, at least, rises to such a height as the water never exceeds.

This operation ought to be performed as early in summer as possible, and the slope should be either immediately covered with turf, pared from the surface of some field that has a very strong sward upon it; taking care to lay these in such a manner as to be in as little danger as possible of being washed away by any accidental flood that might happen before they have grown together; or, if the turf of this kind cannot be easily had, it should be sowed very thick with the seeds of some small mat-rooted grass, that should be kept in readiness for that purpose *.

* The creeping meadow grass, *Poa repente*, is a proper grass for this purpose.

If the stream has not been extremely rapid at the foot of the bank, some of the earth that was thrown into the water will be allowed to subside to the bottom, and will there form a bed of loose soft earth, which will be of very great use afterwards in preventing the face of the bank under water from being washed away. But, in order to secure this bulwark effectually for the future, the surface of this soft earth ought to be instantly stuck full of the roots of bog-reeds, flags, water-spiderwort, rushes, and other matt-rooted aquatic plants; which, if allowed to remain till they have once struck root, will afterwards form a barrier that nothing will ever be able to destroy. (See Fig. 8th which represents a river with a high bank A and Fig. 9th, where the same bank is cut into a slope, and part of it thrown into the river and aquatic plants growing thereon at B*).

But

* If there were a necessity for producing any other authority, than the daily experience of every observing man, to prove, that aquatic plants are not only the best means to be employed for preserving the earth from having encroachments made upon it by the water, but even for enabling it to gain upon that element, I would mention the ingenious Mr. Hafslequift, who takes notice of a particular aquatic plant that grows upon the banks of the Nile; to the growth of which he does not scruple to say, that Egypt owes the formation of the whole country that is called the Delta; which, every body knows, has been entirely gained from the sea, without any human industry whatever.



Fig. 4.

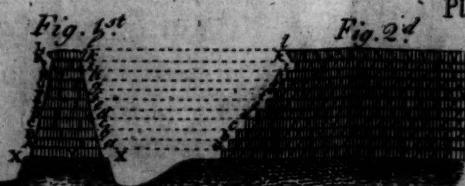


Fig. 5.

Fig. 2.



Fig. 8.

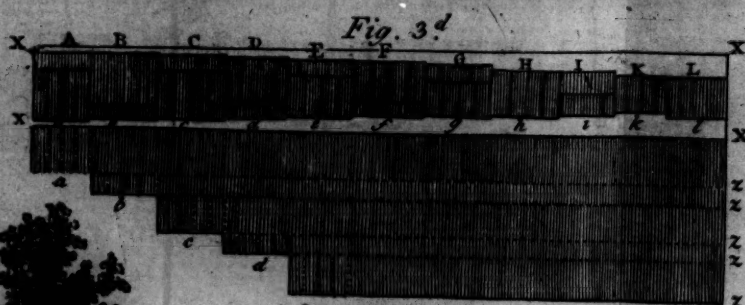


Fig. 3.



Fig. 9.



Fig. 5.



Fig. 10.

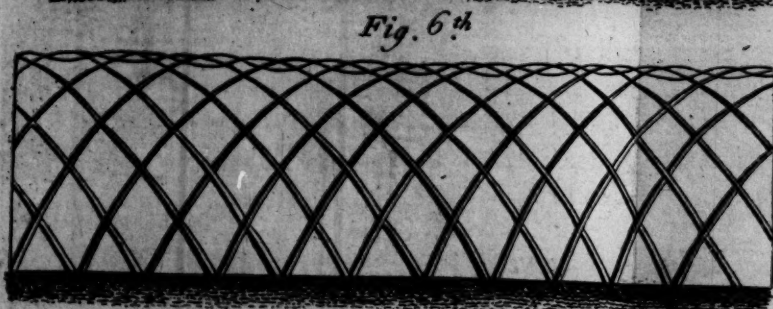


Fig. 6.

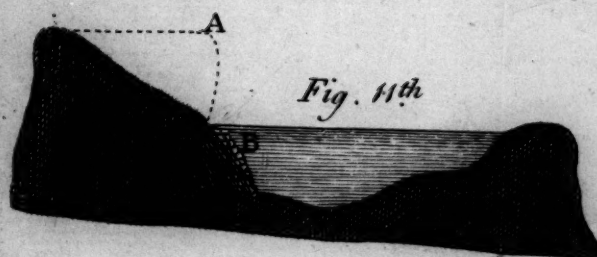


Fig. 11.

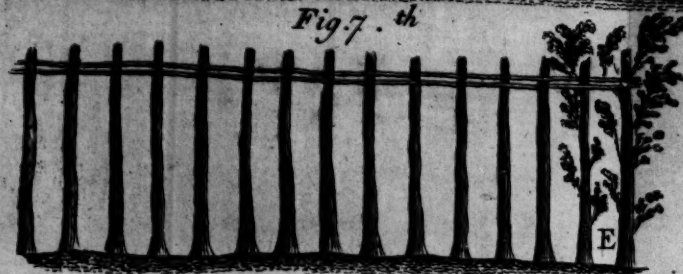


Fig. 7.



Fig. 12.

But, if the stream be too rapid to admit of this, and the bank of soft earth is much deeper than the surface of the water, (as in Fig. 10th,) it will be of great use to fill up the breast of the bank with loose stones carelessly thrown in, till they rise near the surface of the water, which would most effectually secure it against any future encroachments, if the bank is sloped away above, (as at Fig. 11th).

But, if it should so happen that stones cannot be easily got for this purpose, the only resource that in this case remains, is to dig the bank so low as that, at the undermost edge, it may be always below the surface of the water, and carry it out in this way for a considerable distance, and then stick the whole surface that is below the water full of matt-rooted aquatic plants; which will, in a great measure, if not entirely, defend it from any future encroachments.

This bank ought to continue to shelve downwards even where it is below water, (as at Fig. 12th), and those aquatics, that will grow in the greatest depth of water, be planted on the innermost brink, and the others behind them. The water spider-wort will grow in four feet depth of water, and the roots of the common yellow-flowered water-iris forms such a strong and compact covering upon the surface of the soil on which it grows, as would defend it from being affected by the water almost as well as if it were a rock. It is likewise an advantage attending this plant, that it grows upon

a firm bottom, and chiefly delights in running-water.

If the stratum of soft earth is not so deep as reach to the surface of the water, and lies upon a stratum of rock or hard gravel, there will be no occasion for throwing in stones of any kind. But, as it is difficult to unite the vegetable mold to any of these strata, there will always be some danger of its separating from them in violent inundations; and if the water once get an entry, it will not fail to grow larger and larger by every future inundation. To prevent this inconvenience, it will be necessary, after you have sloped the earth away till you reach the gravel or rock, to cover the place where the edge of the earth joins the inferior stratum, with a good many small stones, if they can be found; sowing between them the seeds of any kind of plants that you think are most likely to thrive, which have strong matted roots, with as small and flexible tops as possible.

You will easily observe, that, from the impossibility of ever making earth adhere firmly to stone of any kind, it must always be an improper practice to face the banks of a river to a certain height with stone, which is coped at top with earth.

By these precautions, or others similar to them, it is not to be doubted, but that almost all the banks that are hurt by these accidents might be effectually secured.

§ XXIX.

Of Fencing the Banks of Rivers, so as to confine the Water within proper Bounds, and prevent the Damage that might be done by its overflowing the Fields upon its Banks, in the Time of Inundations.

Another mischief occasioned by the swelling of rivers, not less considerable than the foregoing, is produced by the water overflowing the rich flat ground that is frequently met with on the sides of rivers, which sometimes prevents them from being got laboured at the proper season, sometimes sweeps off at once the whole crop, and sometimes destroys it by covering the whole surface with stones and gravel, to the unspeakable detriment of the possessors of such ground. And, as these *haughs* * are generally very rich and fertile, and some-

* *Haugh* is a name peculiarly appropriated, in the northern parts of Britain, to denote those low flat lying fields that are frequently met with upon the sides of rivers, and is applied to no species of ground in any other situation whatever. As the word is expressive, and conveys a distinct idea that can be expressed by no other single word that I know, I have chosen to retain it here; although I am sensible, that, perhaps, one half of the inhabitants of this island can hardly pronounce this combination of letters. If the reader knows any word that could be substituted in its stead, it will be easy for him to reject the term entirely.

sometimes of very great extent, the damage that is done by not getting them properly cultivated, is very considerable. As this is an object of very great consequence to the public, and of importance to many individuals, it appears to me not a little extraordinary, that no attempt to remedy this evil has hitherto been published; at least as far as I know. And, as it is greatly to be wished that some method could be contrived to preserve these fields from this inconvenience at an easy expense, it is hoped, that the following attempt to accomplish this, will be received by the public with some degree of indulgence, even if it should be found to be more defective than the writer hereof may at present apprehend.

These haughs are seldom of great extent, excepting in level tracts where the water runs with no impetuous current; and therefore, they may, in general, be preserved, by means of a sloping bank raised all along the side of the river as far as the haugh extends; which, if formed after the same plan as those described in the last article, will easily confine the water within their boundaries, till it rises so high as to flow over the top of the bank; so that, if these are raised to a sufficient height towards the back part, in such a manner as to be capable of containing the whole of the water that
at

at any time flows down the river, the fields on each side will be effectually secured.

If the surface of the ground in the haugh is at any considerable height above the water in the river, as at AB, (Fig. 13th,) the bank may perhaps be raised to the necessary height, by throwing the earth that is taken from the brink of the river at A, (Fig. 14th,) to the other side of the bank, at B, so as to form the new surface of the bank in the direction CD, instead of the old surface AB. But, if the surface of the ground is lower, as at EF, (Fig. 13th,) on the opposite side of the river, the earth that is taken from the triangle FGH, (Fig. 14th,) will not, in that case, be sufficient to fill up the whole triangle GIK, and raise the bank to a proper height: To make up which deficiency, it will be necessary to dig a ditch KLE, at the back of the bank, throwing the earth into the higher part of the bank GIK, and facing up the line IKL with stones or turf, so as to make it become a fence to one side of the field that it preserves from inundations.

But, if the surface of the ground is extremely low, so as to be but little above the level of the water, as at LM, (Fig. 15th and 16th,) then, instead of raising the banks on each side to the height of AB, (Fig. 16th,) it will be more advisable to raise them only to the height of the line EF; as in that case it would be very difficult to find so much earth as would form the banks at AKD and CGB, although there will

be no difficulty in forming the smaller ones KEL, and GFM: And, as the area EFGCDK, is equal to the area ABCK, these lower banks will contain an equal quantity of water within them, as the higher ones would have done; the greater width between them making up for their want of height.

In this way, it will be in the power of any man so to proportion his banks to the circumstances in which he finds himself placed, as in the easiest manner to accomplish his design; for, if he has plenty of materials at hand, he may rear his banks to a greater height, and confine the river to a narrower course; and, if he finds a deficiency in that respect, he may make them of a smaller height, and allow the river to spread to a greater breadth.

§ XXX.

Method of securing the Fields thus defended from the River, from the Danger of being overflowed by extraneous Water coming from the high Ground behind them.

It is necessary to defend these haughs, not only from the inundations of the river, but also to preserve them from being overflowed by any other water that might come down upon them from higher ground. On this account, it will be necessary

necessary to allow any rivulets that may flow through these, to fall into the river without any obstruction; banks of the same kind being continued along each side of these as far as the haugh-ground extends. And, if the back part of these haughs, where it borders with the higher ground, be bounded with a good ditch to intercept the water that may fall from it, with openings at proper places into the river, they will be effectually secured from all extraneous water whatever, and remain quite dry, while the water all around them is higher than the surface of the ground in them, if the possessor shall so incline.

To illustrate this more distinctly, I have subjoined the plan of a small part of a river, with haughs on each side of it, secured in this manner (at Fig. 17th), in which AB represents the river secured by its bank on each side; C and D, rivulets that fall into it, confined by banks on each side of them, as far as is necessary; EFG is the ditch that separates the low from the high ground; which receiving the water that descends from the heights carries it in the direction EF, till it falls into the rivulet upon the other side; and, on the other side falling towards G, it flows on till it comes to some other part, where it may be found necessary to make an opening for it into the river. The lines H, I, K, are the dikes dividing the haugh into fields of a moderate

rate extent, which may be nearer or farther from one another as the field has more or less declivity. These dikes should be of a considerable thickness, and may be formed of the earth taken from a ditch on each side thereof, (as at Fig. 19th,) which ditch should be carried quite round each of the fields, in order to receive and carry off any water that may fall upon them, or any moisture that may ooze out of springs.

§ XXXI.

Of freeing the Fields, thus fenced, from Water that might arise from Springs within the same.

But, it is not only necessary thus to secure our fields from being hurt by water from the river or higher ground, but also, to provide an outlet for the water that may be within them. For, unless such outlet be provided to carry off the superfluous water that may fall upon these fields from the clouds, or rise from springs within them, our improvement would be very imperfect. On this account, it will be necessary to be attentive, when forming the bank, to leave a small conduit at the lowermost corner of each field, as is represented by the dotted lines L, L, L, L. Each of these should be carried quite thro' the bank from the ditch L, (Fig. 14th,) as represented by the dotted lines L, H, and should be built of solid mason-work, well rammed

rammed at the back with soft clay, to render it quite impervious to water. At L, (Fig. 14th,) there should be formed a close water-fluice that could be opened or shut at pleasure; and, on the other end of the conduit, at H, there should be a wooden door with the hinges upon its upper-side, so as to make it open with its back towards the stream; by which means, when the water of the river rises above the level of the line LH, it will press upon the back of the door, so as to shut it, and prevent the water from flowing into the field at that time; and, when the river again falls to its ordinary level, the door will be easily forced up by the pressure of the water from within, if there has been any accumulated there during the time of the inundation, and it will be allowed to fall easily into the river.

This kind of fluice is well known, and has been frequently described; but, as it is difficult to get them made to close so exactly as to admit of no water at all, I have directed to employ likewise the inner-fluice at L, which could be made to shut more accurately, and could be closed upon extraordinary occasions; and the folding fluice would be of use to keep out a good deal of the water when the inundation happened in the night time, or so suddenly as to be pretty high before the farmer could have time to get the inner-fluice stopped. The inner-fluice alone would be entirely sufficient, unless where there
happened

happened to be springs within the field; which being kept in general shut, could be opened when occasion might require.

§ XXXII.

Directions for floating these Fields at Pleasure.

But this is not the only use that might be made of these sluices. Water is only prejudicial to the farmer when it comes at improper seasons, or in an impetuous manner, or remains longer upon the ground than he might incline; but, if it is entirely under his command, he may often employ it with very great advantage. Many of the fields in Holland are covered all winter with water, and are, by this means, rendered extremely fertile. And, as all rivers during inundations are strongly impregnated with the finest particles of vegetable mold, and rich manures washed away from fertile fields by the violent rains, it is not to be doubted, but that, if the water, when in this state, was allowed to glide slowly in upon a field till it was covered with it to a considerable depth, and there detained in a stagnant state till all these fine *faeculae* were deposited upon the field, and was then drawn gently off, it would afford a very rich and valuable dressing, somewhat similar to that which annually fertilizes Egypt by the overflowing of the Nile. For this river,

coming

coming with great rapidity through the country of Ethiopia, enters Egypt strongly impregnated with the best vegetable mold; and, gliding slowly over these level plains, being still farther retarded in its course by the north wind, which at that time continually blows upon this coast, the earth is allowed gradually to subside, and forms that rich slime which covers the whole country when the Nile retires within its bed, and gives to it that amazing fertility for which Egypt has been famous since the earliest ages of antiquity. Now, although it is not to be expected, that an inundation which continues only for such a short time, and rises to such an inconsiderable height above the surface of the earth, as any that we ever experience, could produce such great effects as this more perfect annual overflowing does with them; yet, by the contrivance I have mentioned, the farmer might reap the same improvement in kind, although not in degree; and, having it in his power to repeat it as often as an inundation happened, if he should so incline, it is hard to tell what a degree of fertility this might produce in time.

To obtain all these advantages, when he wishes to lay any particular field under water, he needs only to put a gag into the folding sluice, so as to prevent it from shutting close; and having, at the same time, opened the inner-fluice,

fluice, allow it to remain in that state till an inundation happens; at which time the water from the river will enter freely by the conduit, and flow gently in upon the field till it rises to the same height with the river. And, when it is as high as he inclines, he may shut the inner-fluice, which will detain the whole of the water in the field as long as he shall think proper; and, when the river is fallen in, and the water has deposited its sediment, he may open the fluice and let it run off at leisure.

In this manner, these fields may be richly impregnated, and kept in high order, with the greatest ease to the farmer, instead of having the crops of them frequently destroyed, and the finest mold washed away, as is usual, by the ordinary way of management.

But, although this method of admitting the water might answer very well in those situations where the ground is so low as to be considerably below the surface of the water in the river in ordinary inundations; yet, to such as lie so high as to be above the level of the water, excepting upon very extraordinary occasions, it could be of very little service. And, as it will always be of great use, on every occasion of this sort, to cover the field to as great a depth of water as possible; it will, in general, be prudent, in every man who means to avail himself of this circumstance, to introduce the

the water to his fields in the following manner.

As every river flows downwards in its course in a lesser or greater degree, it is in the power of any one who chuses it, to raise a small current of water drawn from the river, to some height above the level of its surface, at any particular place, merely by cutting a tract for it upon the bank, and making it flow in a bed nearer a horizontal direction than that of the river, as we see daily practised with regard to mill-leads, (mill-races,) &c.

Now, with regard to the present case, it may be in general in the power of those who wish to make an improvement of this kind, to take off a small water-course so far up the river, as to be able to raise it to a height equal with the top of the bank that is raised for fencing his fields. And, if this can be done, it would be the easiest thing imaginable to form a small hollow on the top of the bank when first made, as at A, (Fig. 18th,) to serve as a bed for this small stream of water to run in when it should be found necessary. And, by having a sluice upon the upper part of this canal, to open or shut at pleasure, the water might be admitted into it when, and only when the possessor of it should incline. And, if there was a particular sluice that opened from this canal into each of the fields, it would be in his power to throw

throw it upon any one of these at any time that he saw proper, and raise it as high in it as the top of the bank, if he chose it.

I decline enumerating any more of the advantages that would attend this practice, as these must appear obvious at first sight. It is only necessary for me here to take notice, that, if the banks which form the boundaries of these inclosures are not made very thick and strong, as was already advised, they would be altogether insufficient for bearing the pressure of such a body of water as is supposed to be sometimes contained in some of these, while the other fields around them are empty. On which account they ought, in general, to be made of a triangular form, (as in Fig. 19th.)

Those who may not have the convenience of being able to bring the water, as here described, may frequently have it in their power to lay these fields under water when, or to what depth they may incline, by diverting from its right course, any rill that may fall from the higher ground near them, and introducing it into the field, when swelled with rain.

§ XXXIII.

Of Fencing and Securing flat Meadow-grounds from the Danger of being drowned, or of floating them at pleasure.

Besides the level grounds on the banks of rivers just now described as apt to be hurt by

by extraneous water, there are many large tracts of ground of another kind to be met with, that are in as great danger of receiving damage from this cause as the former. These consist of low level grounds lying in a bottom surrounded with higher ground, from which the descent is so inconsiderable as not to allow the water to flow away from them so fast as it comes upon them during the continuance of violent rains; which subjects them to the disagreeable inconvenience of being frequently overflowed at improper seasons, so as to prevent the farmer from having it in his power to improve them as he might incline; which grounds are commonly known in the north of Britain by the name of *Meadows* or *Laighs*. As it is of consequence for common farmers to know the way of fencing these, I shall add a few words with regard to them; although others of a more comprehensive understanding may, perhaps, think it unnecessary, after what has been already said.

As the inconvenience complained of in this case arises entirely from water that falls from higher ground, the first step that is necessary to be taken, is, to defend the fields from that, by fencing them all round the sides by a ditch and bank like those already described, of a sufficient size and strength to contain and carry off the whole water that may fall into it at any

time. This ought to be continued all round, and to fall into the main drain by which the water is ultimately conveyed from this level bottom.

If the descent from this be very small, so as not to allow of a swift current of water, make the ditch of a considerable width, and clean it frequently from the mud and weeds that will, in a short time, be in danger of choaking it up entirely. This ditch, or water-course, being made in the lowest part of the ground, must be secured on each side with a bank, like those already described upon the side of the river; and through that let there be made a small conduit, passing from the lowest part of each field, (as at LL, Fig. 17th,) into the drain. But, as the current of water is here supposed to be very small, each of these must be closed with a water-fluice to be opened or shut at pleasure by the hand, and not by folding sluices, which could in this case be of no use.

The meadow may be divided into as many inclosures as shall be thought necessary, by means of earthen banks, (A, Fig. 19th,) raised to any height above the level of the ground, that may be thought necessary, by means of earth taken from the ditch on each side of it, B B. And, upon the top of each of these banks, plant a fence of poplars, willows, or elms, (as described in § XXIII.) which will soon become a defence

a defence against cattle, and shelter the fields from wind, while the bank is sufficiently strong to resist the pressure of the water when you shall chuse to let it into any one field, and effectually prevent it from having any access into any of those that may be around it. If you have not poplars, good truncheons of any of the strong growing kinds of willows may, in this case, be successfully employed.

In this manner, these meadows may be kept constantly, either wet or dry, as the possessor may incline; and have the same advantage from watering as the haughs above described. I have seen many extensive tracts of very valuable land of this sort; which, by being fenced and divided in this manner, might have been made of three or four times its former value, at an expense so inconsiderable as to be scarce worth mentioning. There are, indeed, some situations so very low, that it might be on some occasions necessary to raise the water out of them by artificial aids, as is done in Holland, and perhaps in many other low countries; but there are many extensive tracts that are just now in a great measure useless, that might be perfectly recovered by this method of inclosing, without any other aid whatever.

I make no doubt, but that these methods of fencing are well understood and practised in the fens of Cambridge, Lincolnshire, &c. with

others perhaps more efficacious than any of these.—But, it is not to instruct adepts, like the inhabitants of these counties, that I write, but the industrious farmer who may not have had access to see these improvements.

§ XXXIV.

Observations on the most oeconomical Way of making Fences where Rills or running Water is the Boundary.

It is imagined, that, by employing one or other of the kinds of fences already mentioned, it will be in the power of the farmer to secure almost every field that he can be possessed of, whatever its situation may be. But, some cases may occur, in which he will find much greater difficulty than others in this respect. This he will find to be particularly the case, where he means to fence any ground that is bounded by any kind of stream of running water. When this stream is considerable, it may be in some measure fenced (as is described in § XXIX.); as the river would form upon one side a boundary sufficient for sheep, which might be employed for eating the grass that should grow upon the banks. But, where it is only a rivulet, or small rill, this could not be practised. And, if we attempt to make a fence of any kind that shall be washed by the water in its course, it
will

will always be found difficult to execute, and next to impossible to preserve in proper order, unless where the declivity is so small as never to allow of a brisk current of water at any time. It will, therefore, be prudent in the farmer to avoid making fences in this situation as much as possible.

But, unluckily for the views of the improver, it happens that, as running water forms such a natural and easily defined boundary in an open and uncultivated country, these rills are most commonly employed as marches between the grounds of one proprietor or tenant and another; so that the possessors of all such fields find themselves under the necessity of making fences in these places.

Where this is the case, and the proprietor of the adjacent ground will not agree to make any exchange of ground, this inconvenience must be submitted to as an evil that cannot be removed. But, in all cases where it can be done, it would be much for the interest of both parties to alter the march, so much as to allow a fence to be reared upon it, on solid ground; making the rill entirely the property of one man for a certain part of its course, and entirely the property of the other, at another part of its course, (as is represented in Fig. 20th), where ABCL represents a small rivulet flowing in its natural serpentine course, which
is

is supposed to have been the march between two different farms, X and Z; the possessors of which, for their mutual accommodation, have agreed to make the line DEFGHI, &c. the march in all time to come; so that the proprietor Z, gets the rivulet entirely upon his own farm from A to B, and from C to L; and the proprietor X enjoys it, as entirely as his own, from B to C; each of them reserving to himself, if need be, a liberty to bring a small canal from the rill, as at M and N, to afford water to the cattle in his inclosures.

By this means, the fences will not only be more easily made and kept in repair, but the fields will likewise be more properly divided, and admit of being more œconomically employed, than if a large ditch had been dug as a bed for the rill, and employed as a fence, as is commonly practised in cases of this kind. For, as rivulets of this sort usually run in a sort of level strath*, which extends to some distance on each side the water-course, before the fields on each side begin to rise from it; this level piece of low ground being frequently overflowed by the swelling of the rill, and being moreover continually kept moist by the water running at no great depth below its surface,

* *Strath* is a narrow piece of low ground contained between hills, or any sort of higher ground of considerable length in proportion to its breadth.

is rendered extremely fertile, and is much richer pasture than the drier ground on each side of it, so as to be of very great value to the farmer, and requires to be managed in a very different way from what would be proper for the higher ground on either side of it. But, when a large ditch is made, and that becomes the fence, it draws off the moisture from this level ground entirely, so that it, in a very short time, loses a great deal of that fertility for which it used to be so remarkable. And, as this low ground comes to be thus joined with the rest of the field above it, the farmer is subjected to a good deal of inconvenience. For, as it is usually of a nature so different from the rest of the ground, it can neither be ploughed, sowed, nor reaped at the same time with the other parts of the field, nor manured in the same manner; nor, on many occasions, can be sowed with the same species of grain. But, by altering the march, as described above, it is plain, that all these inconveniencies are entirely obviated. For, by running the march-fence along the line that divides the ground of different qualities, he throws all the meadow-ground to one side; and, by erecting another fence on the opposite side of the rill, between the high and low ground, (as is represented by the dotted lines OF, EH, and GP), the ground of different qualities are kept separate, and may each
of

of them be managed in the manner that shall be thought most proper for it.

§ XXXV.

General Observations with regard to the proper Division of a Farm into Inclosures.

Before I conclude this essay, I shall beg leave to make one other remark with regard to the distribution of inclosures, that may, perhaps, on some occasions, be of use to the young improver; and that is, to be guided in general, with regard to the form and disposition of his inclosures, rather by the nature and site of the ground, than by any ideal form of beauty that he may conceive, from exact regularity in a plan drawn upon paper. Nature will in no case admit of being directly thwarted in her operations; and all that industry ought to attempt is, to pursue her footsteps, observe her dispositions, and gently bend them, where it can be done, to make them concur with our designs.

Among men of taste, that extravagant fondness for straight lines, and perfect uniformity, which for some time past so universally prevailed, is now justly exploded. But, let not the judicious farmer be hurried away into the opposite extreme, by following too closely the idea of beauty that modern improvers have adopted.

adopted. Ornament with him ought ever to be but a secondary consideration; and, as straight lines are always the most convenient boundaries for his fields, let him never deviate from that, but where the situation of his ground absolutely requires it. But, where his ground is so irregular as not to admit of these, it would be folly in him to attempt it.

For ground that is to be kept in tillage, it will be of consequence to study, as much as may be, to have the fences of the two sides parallel to one another and straight, as at *QQQ*, (Fig. 20th); but it is of much smaller consequence to have the boundaries, at the two ends of the ridges, either straight or parallel to one another; and, therefore, on occasions which may require it, the farmer ought always to humour the situation of the ground in those fences that are opposite to the ends of the ridges, as in the curve line *FGP*, (Fig. 20th) which is supposed to be the natural form of the banks of the rill, rather than the straight lines *ON*, *NG*, *GT*, or any other straight line whatever.

Nor ought the oeconomical farmer to consult only the situation of his grounds, but also their quality, when he means to divide them into inclosures. For it often happens that two fields of very different qualities lie quite contiguous to one another; and if these, for the sake of regularity, should be included in the same inclosure,

closure, and form, perhaps, different parts of the same ridge, he may very soon lose more by the damage that the one part may sustain than his being obliged to labour it improperly along with the other, than he can gain by the greater quantity of work that he can perform in a regular than in an irregular field. He will, therefore, in general, make it his study to have all the ground in one inclosure as much of the same quality as possible; and make the exact regularity of his field, in some measure, give way to conveniency in this respect; although he will not be so scrupulously attentive hereto as to distort his fences for every trifling inequality in this respect.

* * * * *

The foregoing sheets were thrown off before I had an opportunity of perusing Mr. Boutcher's judicious Treatise on Forest Trees. It gives me much satisfaction to observe, that the opinion I have been obliged from experience to adopt, of the necessity of having a rich soil for a nursery of thorn-plants, is so strongly confirmed by the experience of that attentive nurseryman.—In some respects, that gentleman recommends a mode of culture for rearing hedges different from that which I have most approved of: But, upon a careful

To front p. 107.

Plate II.

Fig. 13th

Surface of the Water

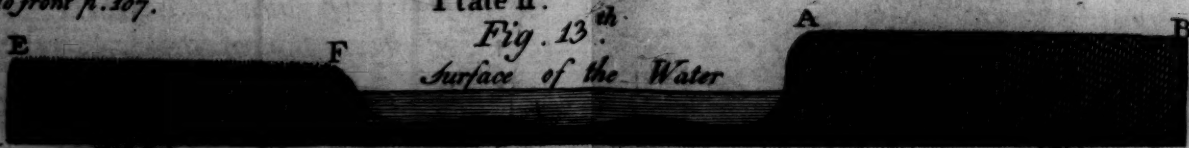


Fig. 14th

Surface of the Water

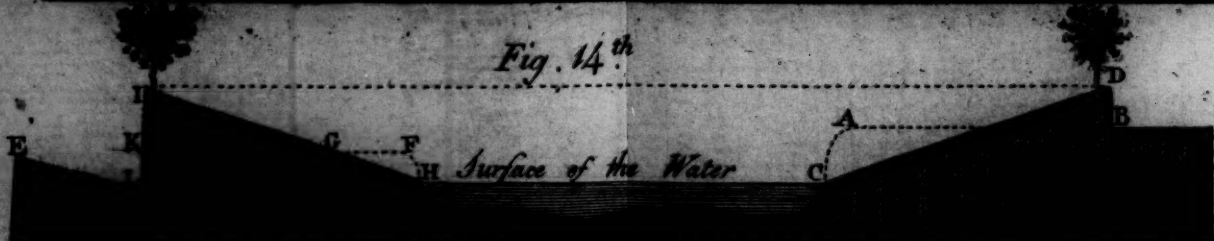


Fig. 15th

Surface of the



Fig. 16th

Surface of the Water

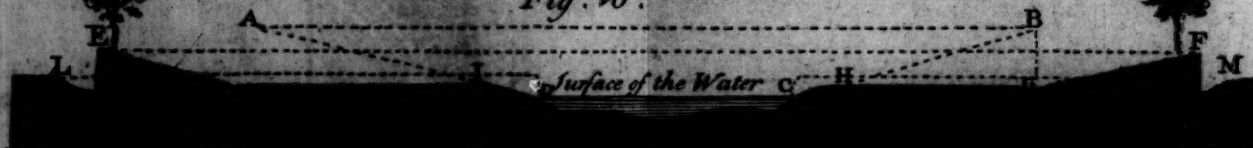
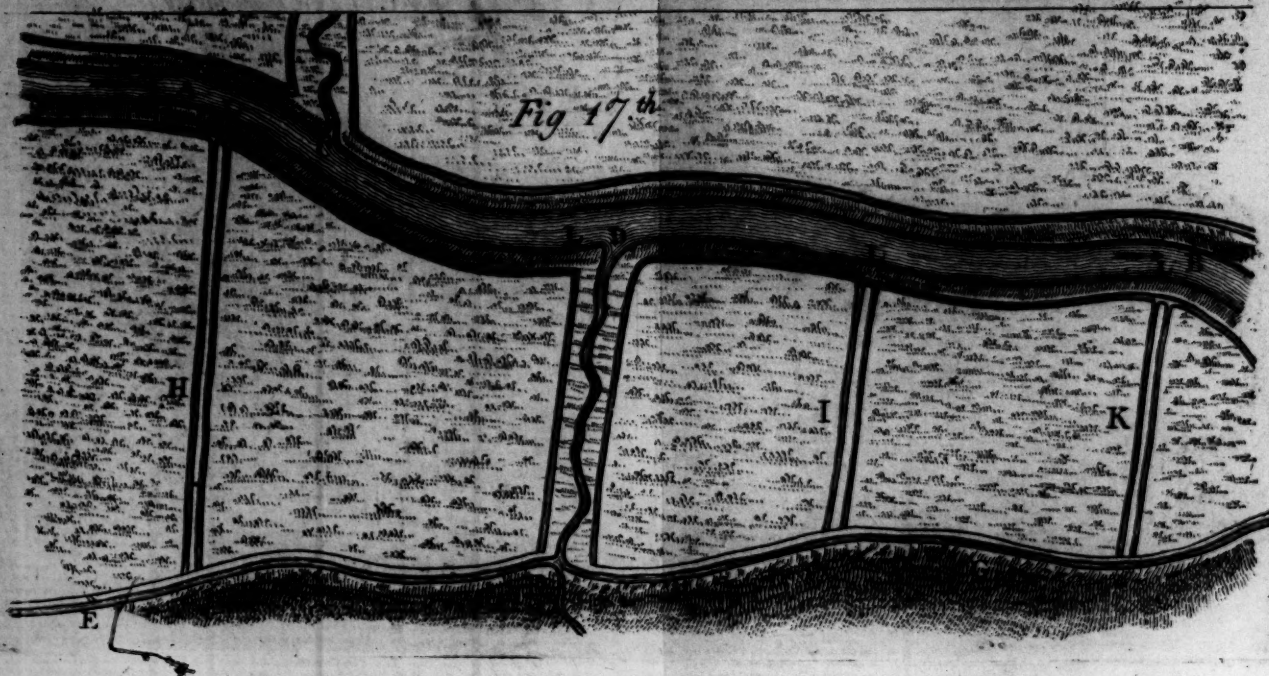


Fig. 17th



ful revisal of what has been advanced in the preceding pages, I find no reason to alter any thing that has been said on that head. His experience has been chiefly in the garden, or in rich sheltered parts of the country;—mine has been in the fields, and in exposed situations. This will account for his approving of some modes of practice that I have not, nor can recommend. Those who are in a similar situation with himself may, without danger, adopt his practice—what I have recommended will answer as well in these situations, and is the only practice I have yet seen that can be successfully followed in others that are more unfavourable. My aim has been to extend this improvement to the bare and exposed fields of Scotland, where the difficulty of rearing hedges is much greater than those who have lived in sheltered countries can well imagine.

I might answer some objections he has made, and point out the reasons for my retaining some opinions different from him:—but, thinking this would only, without necessity, add to the bulk of this volume, I chuse to engage no farther at present in this discussion.

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I



E S S A Y II.

ON

D R A I N I N G B O G S

A N D

S W A M P Y G R O U N D.

E S A Y



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ESSAY II.

ON DRAINING BOGS and SWAMPY GROUND.

Necessity of removing superfluous moisture from the soil—Of springs—A philosophical account of the origin of these—Of spouting sandy soils—method of draining these—Of wet soils arising from an under-stratum of clay—method of draining these—High ridges on such a soil pernicious—and why—Drains in the furrows of such ridges of no utility—and why—Of the bog or quagmire—Manner in which this is formed—An efficacious method of draining bogs described, as practised with success by the author.

IN the preceding Essay, I have shewed, that water may, on some occasions, be of great utility to the farmer; yet, as there are few things more prejudicial to him than a superabundance of it, when too long continued upon the ground, it behoves him to guard against this evil as much as he possibly can; and, at almost any expence, to free his ground from it, if he hopes to make any considerable improvement thereon. For, unless this be first done, all his other operations will turn out to little account.

The

The methods of drawing off stagnant water, which may be accumulated in any low situation for want of a proper outlet, are in general so obvious to every man of discernment, who examines the situation of the ground, that I shall not tire the patience of the reader by enlarging upon that head; but shall proceed immediately to treat of the most proper methods that I have ever experienced of draining such ground as is hurt by springs oozing out of them, (usually distinguished by the name of wet, or *spouting* ground) and bogs *, as this is a matter of much greater difficulty than the former, and the principles upon which it should be conducted, far less generally understood.

Springs are formed in the bowels of the earth by water percolating through the upper strata, where they are of a porous texture, which continues to descend downwards till it meets with a stratum of clay that intercepts it in its course; where, being collected in considerable quantities, it is forced to seek a passage through the porous strata of sand, gravel, or rock, that may be above the clay, following

* It will appear to the reader, that the term *bog* is here employed in its most unlimited acceptation, denoting any kind of quaggy ground arising from too much moisture; and not according to the usual meaning of the word in Ireland, where it, for the most part, only denotes what is in Scotland called peat-moss.

the course of these strata till they approach the surface of the earth, or are interrupted by any obstacle which occasions the water to rise upwards, forming springs, bogs, and other phenomena of this nature; which being variously diversified in different circumstances, produce that variety of appearances in this respect that we often meet with.

This being the case, we may naturally conclude, that an abundant spring need never be expected in any country that is covered to a great depth with sand, without any stratum of clay to force it upwards, as is the case in the sandy deserts of Arabia, and the immeasurable plains of Lybia: Neither are we to expect abundant springs in any soil that consists of an uniform bed of clay from the surface to a great depth. For, it must always be in some porous stratum, that the water flows in abundance, and it can be made to flow horizontally in that, only when it is supported by a stratum of clay, or other substance that is equally impermeable by water. Hence the *rationale* of that rule so universally established in digging for wells, that, if you begin with sand or gravel, &c. you need seldom hope to find water till you come to clay; and, if you begin with clay, you can hope for none in abundance, till you meet with sand, gravel, or rock.

It is necessary that the farmer should attend to this process of nature with care, as his success

in draining bogs, and every species of damp and spouting ground, will in a great measure depend upon his thorough knowledge of this, —his acuteness in perceiving, in every case, the variations that may be occasioned by particular circumstances, and his skill in varying the plan of his operations according to these. As the variety of cases that may occur in this respect is very great, it would be a tedious task to enumerate the whole, and describe the particular method of treating each. I shall, therefore, content myself with enumerating a few particular cases, to show in what manner the principles above established may be applied to practice.

Let Fig. 21st represent a perpendicular section of a part of the earth, in which AB is the surface of the ground, beneath which are several strata of porous substances which allow the water to sink through them till it reaches the line CD, that is supposed to represent the upper surface of a solid bed of clay; above which lies a stratum of rock, sand, or gravel. In this case, it is plain that, when the water reaches the bed of clay, and can sink no farther, it must be there accumulated into a body; and, seeking for itself a passage, it will flow along the surface of the clay, among the sand or gravel, from D towards C; till at last it issues forth, at the opening A, a spring of pure water.

If

If the quantity of water that is accumulated between D and C is not very considerable, and the stratum of clay approaches near the surface, in that case, the whole of it will issue by the opening at A, and the ground will remain dry both above and below it. But, if the quantity of water is so great as to raise it to a considerable height in the bed of sand or gravel, and if that stratum of sand is not discontinued before it reaches the surface of the ground, the water, in this case, would not only issue at A, but would likewise ooze out in small streams through every part of the ground between A and *a*; forming a barren patch of wet sandy or gravelly ground upon the side of a declivity: Which is a phænomenon that every attentive observer must have frequently met with.

To drain a piece of ground in this situation is, perhaps, the most unprofitable task that a farmer can engage in; not only because it is difficult to execute, but also, because the soil that is gained is but of very little value. However, it is lucky that patches of this kind are seldom of great breadth, although they sometimes run along the side of a declivity, in a horizontal direction, for a great length.

The only effectual method of draining this kind of ground is, to open a ditch as high up as the highest of the springs at *a*, which should

be of such a depth as not only to penetrate through the whole bed of sand or gravel, but also, to sink so far into the bed of clay below, as to make a canal therein sufficiently large to contain and carry off the whole of the water. Such a ditch is represented by the dotted lines *a, e, z*; but, as the expense of making a ditch of such a depth as this would suppose, and of keeping it afterwards in repair, is very great, it is but in very few cases that this mode of draining would be adviseable; and never, unless where the declivity happens to be so small, that a great surface is lost for little depth; as would have happened here, if the surface had extended in the direction of the dotted line *a d*.

But, supposing that the stratum of clay, after approaching to the surface at *A*, continued to keep at a little depth below ground; and that the soil which lay above it was of a sandy or spongy nature, so as to allow the water to penetrate it easily. In that case, even supposing the quantity of water that flowed from *D* to *C* was but very inconsiderable, instead of rising out at the spring *A*, it would flow forward along the surface of the clay among the porous earth that forms the soil, so as to keep it constantly drenched with water, and, of consequence, render it of very little value.

Wetness,

Wetness, arising from this cause, is usually of much greater extent than the former; and, as it admits of an easy cure, it ought not to be one moment delayed. For a ditch of a very moderate depth opened at A, and carried through a part of the stratum of clay, (as represented by the dotted lines A, *k*, *f*.) would intercept and carry off the whole of the water, and render the field as dry as could be desired. It is, therefore, of very great consequence to the farmer, accurately to distinguish between these two cases, so nearly allied to each other in appearance; and, as this can be easiest done by boring, every one who has much ground of this kind ought to provide himself with a set of boring-irons, which he will likewise find use for on other occasions.

I might here enumerate a great variety of cases which might be reduced to the same head with the foregoing: But, as any attentive reader may, after what has been said, be able easily to distinguish these, I shall only in general observe, That every soil of a soft and porous texture, that lies upon a bed of hard clay, whatever its situation in other respects may be, will in some measure be subjected to this disease. And, if it is upon a declivity of any considerable length, the undermost parts of the field will be much damaged by it, unless ditches are thrown up across the declivity, at proper distances

distances from one another, to intercept the water in its descent.

It may not likewise be improper here to remark, that, in cases of this nature, unless where the soil is of a very great depth, the malady will always be encreased, by raising the ridges to a considerable height; as will appear evident by examining Fig. 22d,—in which the line A B represents the surface of a field of this nature, and C D the surface of the bed of clay. Now, if this field were raised into high ridges, as at F, F, F, so as that the furrows E, E, E, descended below the surface of the clay, it is plain, that all the water that should sink through the middle of the ridge, would run along the surface of the clay, till it came to the sides of the ridge L, L, L, L, L, L, which would thus be kept continually soaked with water. Whereas, if the ground had been kept level, as in the part of the field from G to H, with open furrows H, at moderate distances from one another, the water would immediately sink to the clay, and be carried off by the furrows, so as to damage the soil far less than when the ridges are high.

If the soil is so thin that the plough can always touch the clay, the ridges ought to be made narrow and quite flat, as from G to H: But, if there is a little greater depth of soil, then it ought to be raised into ridges of a moderate

rate

rate height, as from H to K, so as to allow the bottom of the furrow to reach the clay. But neither is this necessary where the soil is of any considerable depth.

I have seen some industrious farmers, who having ground in this situation, have been at the very great expense of making a covered drain in each furrow. But, had they rightly understood the nature of the disease, they never would have thought of applying such a remedy; as must appear evident at first sight to those who examine the figure. The success was what might be expected from such a foolish undertaking.

These observations, it is hoped, will suffice as to the manner of treating wet, sandy, or porous soils. I now proceed to take notice of such as are of a stiff clayey nature, which are often very different in appearance, and require a different treatment from these.

Suppose that (as in Fig. 23d,) the stratum of sand or gravel D C should be discontinued, as at E, that the stratum above it should be of a coherent clayey nature. In this case, the water that flowed towards E, being there pent in on every side, and being accumulated there in great quantities, it must at length force a passage for itself in some way; and pressing strongly upon the upper surface, if any one part is weaker than the rest, it there would
burst

burst forth and form a spring, (as suppose at A). But, if the texture of every part of this stratum were equally strong, the water would squeeze through many small crannies, and would ooze out in numberless places, as between A and F, so as to occasion that kind of wetness that is known by the name of a spouting clayey soil.

The cure, in this case, is much more easily effected than in any of the former. For, if a ditch of a considerable size is opened, as at A, towards the lowermost side of the spouting ground, so deep as to penetrate through the upper stratum of clay, and reach to the gravel, the water will rise up through it at first with very great violence, which will gradually decrease as the pressure from the water behind is diminished. And when the whole of the water, accumulated in this subterraneous reservoir, is run off, there being no longer any pressure upon the clay above it, the whole soon becomes as dry as could be desired; and continues so ever afterwards, if the ditch is always kept open. This I speak from experience, I having rendered some fields of this kind that were very wet, quite dry, by this method of treating them.

It will hardly be necessary for me here to put the farmer upon his guard, to be particularly careful in his observations, that he may distinguish

guish between the wetness that is produced from this cause, and that which proceeds from the cause before mentioned. Because the treatment that would cure the one, would be of no use at all to the other.

The attentive observer likewise will readily perceive, that, if any field that is wet from this cause admits of being ploughed, it will be in equal danger of being hurt by being raised into high ridges, with the other kind of damp ground before mentioned. For, as the depth of earth above the reservoir would be smaller in the deep furrows than any where else, there would, of consequence, be less resistance to the water in that place, so that it would rise there in greater abundance. And if, in this case, a farmer should dig a drain in each furrow;—as a considerable quantity of water would rise into them, in some cases, the ground might be improved, or even quite drained thereby; especially if they should have accidentally reached the gravel in any one place; although at an expense much greater than was necessary. I take notice of this circumstance, in some measure to prevent the prejudice that some inattentive observers might entertain against what was said before of this method of draining, from their having accidentally seen some fields that may have been bettered by it.

Bogs

Bogs are only a variety of this last mentioned kind of wet ground; and, therefore, ought in general to be drained after the same manner with them. Clay is a substance that strongly resists the entrance of water into it; but, when it is long drenched with it, it is, in process of time, in some measure dissolved thereby;—loses its original firmness of texture and consistence, and becomes a sort of semi-fluid mass, which is called a bog. And, as these bogs are sometimes covered with a strong scurf of a particular kind of grass, with very matted roots, which is strong enough to bear a small weight without breaking, although it yields very much, it is, in these circumstances, called a *Swaggle*.

But, whatever be the nature of the bog, it is invariably occasioned by water being forced up through a bed of clay, as just now described, and dissolving or softening, if you will, a part thereof. I say only a part, because, whatever may be the depth of the bog or swaggle, it generally has a partition of solid clay between it and the reservoir of water under it, from whence it originally proceeds. For, if this were not the case, and the quantity of water were considerable, it would meet with no sufficient resistance from the bog, and would issue through it with violence, and carry the whole semi-fluid mass along with it. But this would more inevitably be the case,

case, if there was a crust at the bottom of the bog, and if that crust should ever be broken; especially if the quantity of water under it were very considerable. And, as it is probable, that, in many cases of this sort, the water slowly dissolves more and more of this under crust, I make no doubt, but that, in the revolution of many ages, a great many irruptions of this kind may have happened; although they may not have been deemed of importance enough to have the history of them transmitted to posterity.

Of this kind, although formed of a different substance, I consider the flow of the Solway-moss in Cumberland to have been; which, upon the 16th November 1771, burst its former boundaries, and poured forth a prodigious stream of semi-fluid matter, which, in a short time, covered several hundred acres of very fine arable ground. Nor will any one, who is acquainted with the nature of mosses,—who knows its resemblance to clay in its quality of absorbing and retaining water, and its very easy diffusibility therein, be surprised at this; as, from all these properties, it is much better adapted for forming an extensive bog; and, therefore, in greater danger of producing an extensive devastation, by an eruption of the water into it, than those that are formed of any kind of clay whatever.

If

If the bog, or swampy ground, is upon a declivity, the ditch ought to be carried across the field about the place where the lowest springs arise. But, if the surface of the ground is level, or nearly so, as between A and B, (Fig. 24th), and the springs break out in several places, *q q q q q q*, so as to form soft quagmires interspersed through the whole of the field, it will be of little consequence in what part the drain is opened; for, if it is dug so deep as to allow the water to rise in it with freedom, it will issue through that opening, and the field will be left perfectly dry.

But, as it may frequently happen that the stratum of gravel shall be at a considerable depth beneath the surface of the earth, and as it may be sometimes even below the level of the place into which the drain must be emptied, it might sometimes be extremely difficult to make a ditch so deep as to reach the bed of sand or gravel. But, it is lucky for us, that this is not absolutely necessary in the present case; as a drain of two or three feet deep, as at D, will be equally effectual with one that should go to the gravel. All that is necessary, in this case, is, to sink pits (P) in the course of the drain, at a moderate distance from one another, which go so deep as to reach the gravel. For, as the water there meets with no resistance, it readily flows out at these openings, and is carried off by

by the drain, without being forced up through the earth; so that the ground is left entirely dry ever after.

I have likewise drained several fields in this way; and, as I have generally found the appearances pretty much alike, I shall, for the information of the inexperienced reader, give a short account of them.

If you attempt to make your pit in one of these soft quaggy places where the water is found in great abundance, you will meet with very great difficulty in forming it. For, as the substance of which it is composed is soft, it will always flow into the hole as fast as you dig it. On this account, I would advise, not to attempt to make the pit in the swaggle, but as near it in the solid earth as you conveniently can. However, if it is pretty firm, and of no great extent, it is sometimes practicable to make a pit in the soft bog, at the driest time of the year. This I have sometimes practised, which gave me an opportunity of observing the nature of these bogs more perfectly than I otherwise would have had.

In the trials of this kind that I have made, the soft quaggy ground has seldom been above three or four feet deep, below which I have always found a stratum of hard tough clay usually mixed with stones; and so firm, that nothing but a mattock or pick-axe could penetrate it.

And,

And, as this is comparatively so much drier than the ground above it, an inexperienced operator is very apt to imagine that it is the bottom that he is in search of.

In digging through this stratum, you will frequently meet with small springs oozing out in all directions. Some of them that might fill the tube of a small quill, and others so small as to be scarce perceptible. But, without regarding these, you must continue to dig on without intermission till you come to the main body of the reservoir, if I may so call it, that is contained in the rock, gravel, or sand; which you will generally find from two to four feet below the bottom of the swaggle, and which you will be in no danger of mistaking when you come to it. For, if there has been no opening made before that in the field, as soon as you break the crust immediately above the gravel or rock, the water will burst forth like a torrent, and, on some occasions, will rise like a *jet d'eau*, to a considerable height above the bottom of the ditch; and continue to flow off with great impetuosity for some time, till the pent up water being drained off, the violent boiling up will begin to subside, and the strength of the current to abate; and, in a short time, to flow gently out like any ordinary spring.

Allowing

Allowing it to remain in this state for some time, the quaggy earth will soon begin to subside, and gradually become firmer and firmer every day; so that, in the space of a few months, those bogs that were formerly so soft as hardly to support the weight of a small dog, will become so firm, that oxen and horses may tread upon them without any danger of sinking, at the very wettest season of the year.

I have had a field of this nature, that, by having only one such pit as I have now described, opened in it, was entirely drained to the distance of above a hundred yards around it in every direction.

But, as it is possible that the stratum in which the water runs may be in some places interrupted, it will be in general expedient to make several of these pits, if the field is of great extent; always carrying the drain forward through the lowermost part of the field, or as near the quag as you conveniently can; and sinking a pit where-ever you may judge it will be most necessary. But, if the stratum of gravel is not interrupted, there will be no violent burst of water at opening any of these after the first, as I have frequently experienced.

To keep these wells from closing up after they are made, it is always expedient to fill them

them up with small stones immediately after they are made, which ought to rise to the height of the bottom of the drain.

I have often imagined that the expense of digging these pits might be saved by boring a hole through this solid stratum of clay with a large wimble made on purpose; but, as I never experienced this, I cannot say whether or not it would answer the desired end exactly.

If the whole field that is to be drained consists of one extensive bog, it will require a long time before the whole work can be entirely finished; as it will be impossible to open a drain through it, till one part of it is first drained, and becomes solid ground. In a situation of this kind, the undertaker, after having opened a drain to convey the water from the lower part of the bog, must approach as near to the swampy ground as he can, and there make his first pit; which will drain off the water from the nearest parts of the bog.

When this has continued open for some time, and that part of the bog is become so solid as to admit of being worked, let him continue the ditch as far forward through it as the situation it is in will admit of, and there sink another pit; and proceed gradually forward in the same manner; making
cross

cross cuts where necessary, till the whole be finished.

In this manner may any bog, or tract of spouting ground of this nature, be rendered dry at a very inconsiderable expense. And, as there can be no other method of draining ground of this sort effectually, I recommend the study of it to the attention of every diligent farmer who may have occasion for it. Let him first be extremely cautious in examining all the circumstances of his particular fields, that he may be certain which of the classes above enumerated it may be ranked with; and, when he is perfectly sure of that, he may proceed without fear; being morally certain of success.

There is, however, one kind of damp ground not yet particularly specified, that I have purposely omitted taking notice of till this time, as I have never had an opportunity of examining particularly into the nature of it; nor of ascertaining, by experience, what is the most proper method of treating it.—

The soil I have now particularly in my eye consists of a deep strong clay, that does not vary its nature even on the surface, but in as far as manures may have rendered it more friable and tender. The colour usually inclines to a reddish cast; and, for the most part, it is situated upon the side of some de-

clivity. This bed of clay reaches to a great depth, without any variation, and is intermixed with a considerable quantity of small round stones.

Many soils of the sort now described, are apt to be continually moist and full of water during the winter season. But, when the dry weather of summer sets in, the moisture is diminished, and the surface becomes hard; and it is rent into many large gaps, which allow free admision to the sun and air, so as to scorch up almost every plant that is sowed upon it. And, as these soils are usually in themselves naturally fertile when drained, it were to be wished that some method could be discovered that would be less expensive than what is usually practised with regard to some soils of this kind in Essex, where they make covered drains of two and a half feet deep, running diagonally through the whole field, at the distance of twenty feet from each other.

Were I to indulge myself in conjecturing, I might here offer some remarks tending to shew the probable cause of this phaenomenon, and point out an easier method of cure. But, as it is extremely dangerous, for one who pretends to instruct others, to give way to the tempting seductions of a warm imagination, I shall content myself with having
pointed

AND SWAMPY GROUNDS. 131

pointed out this evil to those who may have it in their power to examine into the causes of this particular malady, and to point out to others the easiest and most efficacious cure.

ESSAY III

PROPER METHOD

LEVELLING HIGH RIDGES

K 2 ESSAY

pointed out their evil to those who may have
 in their power to examine into the causes
 of this pernicious malady, and to point out
 to others the cause and most efficacious
 remedy.

It is to be feared that the influence of the
 law, and the power of the government, are
 not sufficient to prevent the spread of this
 disease, and that the only remedy is to be
 found in the power of the people. It is to be
 feared that the influence of the law, and the
 power of the government, are not sufficient to
 prevent the spread of this disease, and that
 the only remedy is to be found in the power
 of the people. It is to be feared that the
 influence of the law, and the power of the
 government, are not sufficient to prevent the
 spread of this disease, and that the only
 remedy is to be found in the power of the
 people.

What is to be done? It is to be done
 by the people. It is to be done by the
 people. It is to be done by the people.
 It is to be done by the people. It is to be
 done by the people. It is to be done by the
 people. It is to be done by the people.

ESSAY K 2

E S S A Y III.

ON THE

PROPER METHOD

OF

LEVELLING HIGH RIDGES.

III.



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OF THE

PROPER METHOD

OF

LEVELLING HIGH RIDGES



Fig. 18.

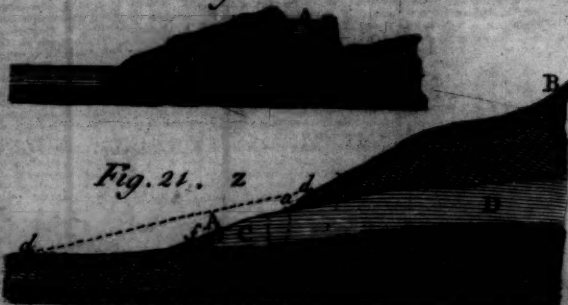


Plate III.

To front p. 135.

Fig. 19.

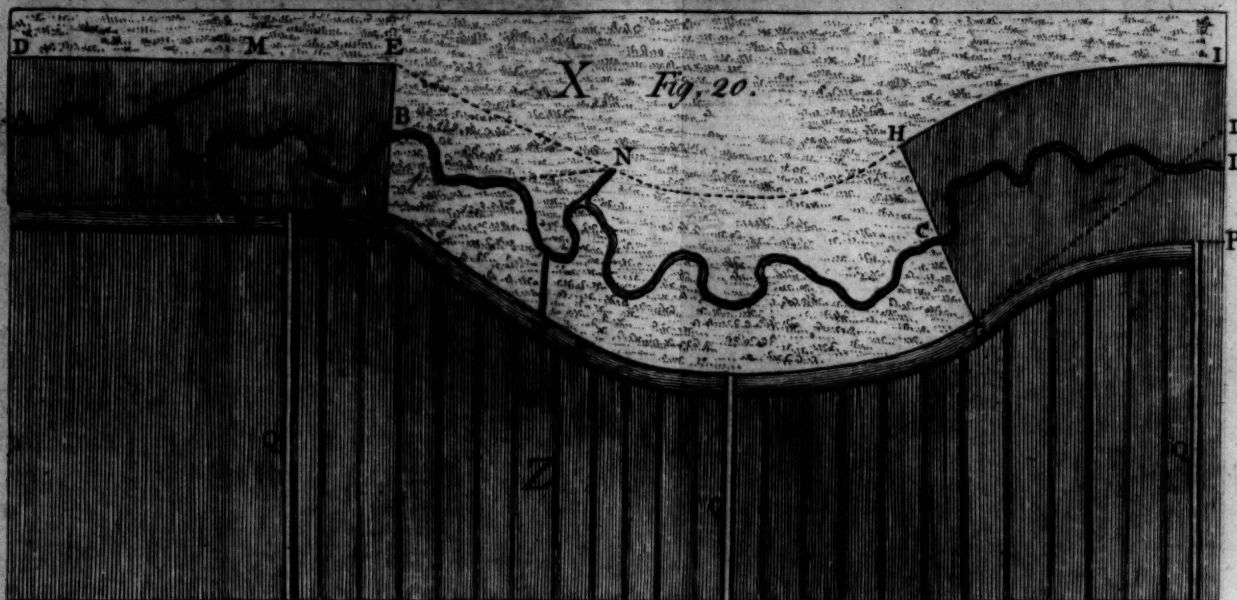


Fig. 22.

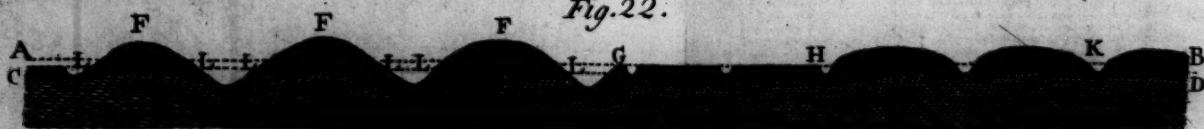


Fig. 23.

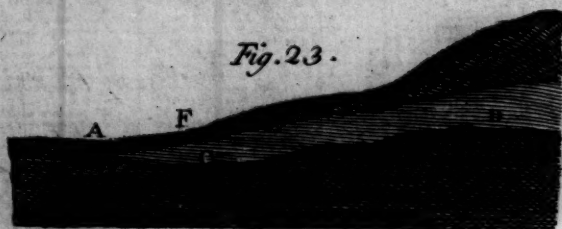


Fig. 24.



E S S A Y III.

On the proper METHOD of LEVELLING HIGH RIDGES.

The difficulty and danger attending the levelling high ridges by the plough, or other levelling machines.—A new method of levelling by the plough and spade described, as it has been, with success, practised by the author.—A calculation of the expense of levelling by this method—not one fourth of that of doing it by the plough—and, in other respects, infinitely more advantageous.—Another less perfect method of performing this operation described.—A caution to young improvers in agriculture not to adopt too many new implements of husbandry.

IT was the practice very universally, in old times, to make the ridges in all ploughed lands crooked like an inverted S, and of very great breadth and height, which, in a great degree, prevents the farmer from reaping the full benefit of many of those improvements that have been adopted in modern times. In some parts of England, it is so long since they began to make improvements in agriculture, that this obstruction to them has been intirely

intirely removed; and the very remembrance of this improper practice has been lost: But in some places there, and through the greatest part of Scotland, it still continues to prevail, to the very great detriment of the industrious improver, as it either mars his operations in a high degree, or subjects him to a considerable expence in reducing them to a proper level; which is greatly enhanced by the very considerable deficiency in his crops, that he must feel for many years, in consequence of this operation, unless it is performed with an uncommon degree of care and attention.

The difficulty of performing this operation properly with the common implements of husbandry, and the obvious benefit that accrues to the farmer from having his fields level, have produced many new inventions of plows, harrows, drags, &c. calculated for speedily reducing the fields to that state; none of which have as yet been found fully to answer the purpose for which they were intended, as they all indiscriminately carry the earth that was on the high places into those that were lower; which, although it may, in some cases, render the surface of the ground tolerably smooth, and level, is usually attended with inconveniencies far greater, for a considerable length of time, than that which it was intended to remove.

For

For experience sufficiently shows, that even the best vegetable mold, if buried for any length of time so far beneath the surface, as to be deprived of the benign influences of the atmosphere, loses its *vis vitæ*, if I may be allowed that expression,—becomes an inert, lifeless mass, little fitted for nourishing vegetables, and constitutes a soil very improper for the purposes of the farmer. It therefore behoves him, as much as in him lies, to preserve, on every part of his fields, an equal covering of that vegetable mold that has long been uppermost, and rendered fertile by the meliorating influence of the atmosphere. But, if he suddenly levels his high ridges by any of these mechanical contrivances, he of necessity buries all the good mold that was on the top of the ridges, in the old furrows, by which he greatly impoverishes one part of his field, while he too much enriches another; insomuch that it is a matter of great difficulty, for many years thereafter, to get the field brought to an equal degree of fertility in different places; which makes it impossible for the farmer to get an equal crop over the whole of his field by any management whatever; and he has the mortification frequently, by this means, to see the one half of his crop rotted by an over-luxuriance, while other parts of it are weak and sickly, or one part ripe, and ready for reaping, while

while the other is not properly filled ; so that it were, on many occasions, better for him to have his whole field reduced at once to the same degree of poorness as the poorest of it, than have it in this state. An almost impracticable degree of attention in spreading the manures may, indeed, in some measure, get the better of this ; but it is so difficult to perform this properly, that I have frequently seen fields that had been thus levelled, in which, after thirty years of continued culture, and repeated dressings, the marks of the old ridges could be distinctly traced when the corn was growing, although the surface was so level that no traces of them could be perceived when the corn was off the ground.

But this is a degree of perfection in levelling that cannot be usually attained by following this mode of practice ; and, therefore, is but seldom seen. For all that can be expected to be done by any levelling machine, is to render the surface perfectly smooth and *even* * in every part, at the time that the operation is performed : But as, in this case, the old hollows are suddenly filled up with loose mold to a great depth,

* I know not if *even*, in the sense here used, is an English word. *Level* denotes, properly speaking, a surface, not only free from inequalities, but also horizontal in position. *Even* denotes, a surface free from inequalities, whatever be the position thereof.

depth, while the earth below the surface, upon the heights of the old ridges, remains firm and compact, the new raised earth, after a short time, subsides very much, while the other parts of the field do not sink at all; so that, in a short time, the old furrows come to be again below the level of the other parts of the field, and the water of course is suffered, in some degree, to stagnate upon them, in so much that, in a few years, it becomes necessary once more to repeat the same levelling process, and thus renew the damage that the farmer sustains by this pernicious operation.

On these accounts, if the farmer has not a long lease, it will be found, in general, to be more his interest to leave the ridges as he found them, than to attempt to alter their direction: And, if he attends with due caution to moderate the height of these old ridges, he may reap very good crops, although, perhaps, at a somewhat greater expense of labour than he would have been put to upon the same field, if it had been reduced to a proper level surface, and divided into straight and parallel ridges.

But, where a man is secure of possessing his ground for any considerable length of time, the advantages that he will reap from having level and well laid out fields are so considerable, as to be worth purchasing, if it should even be at a considerable

considerable expense. But the loss that is sustained at the beginning, by this mechanical mode of levelling ridges, if they are of considerable height, is so very great, that it is, perhaps, doubtful if any future advantages can ever fully compensate it. I would therefore advise, that all this levelling apparatus should be laid aside, and the following more efficacious practice be substituted in its stead; a practice that I have long followed with success, and can safely recommend as the very best that has yet come to to my knowledge.

If the ridges have been raised to a very great height, as a preparation for the ensuing operations, they may be first *cloven* or *scaled* out, as it is called in some places; that is, ploughed so as to lay the earth on each ridge from the middle towards the furrows. But, if they are only of a moderate degree of height, this operation may be omitted,

When you mean to proceed to level the ground, let a number of men be collected with spades, more or fewer, as the nature of the ground requires, and then set a plough to draw a *thurrough* * directly across the ridges of the whole

* I find myself here at a loss for a term, and therefore have been obliged to revive one now obsolete, although exceeding

whole field intended to be levelled. Divide this line into as many parts as you have labourers, allotting to each one ridge, or two, or more or less, according to their number, height, and other circumstances. Let each of the labourers have orders, as soon as the plough has passed that part assigned him, to begin to dig in the bottom of the thurrough that the plough has just made, about the middle of the side of the old ridge, keeping his face towards the old furrow, working backwards till he comes to the height of the ridge, and then turn towards the other furrow, and repeat the same on the other side of the ridge, always throwing the earth that he digs up into the deep old furrow between the ridges, that is directly before him; taking care not to dig deep where he first begins, but to go deeper and deeper as he advances to the height of the ridge, so as to leave the bottom of the trench he thus makes across the ridge entirely level, or as nearly so as possible. And when he has finished that part of the thur-

exceeding proper. By *furrow*, in this treatise, must always be understood the openings, or small drains, on each side of the ridge, and that alone.—By *thurrough* is understood the open trench left by the plough in its ordinary operation. The reader is desired to attend to this distinction.

rough

rough allotted to him, that the plough has made in going, let him then go and finish, in the same manner, his own portion of the thurrough that the plough makes in returning. In this manner, each man performs his own task through the whole field, gradually raising the old furrows as the old heights are depressed. And, if an attentive overseer is at hand, to see that the whole is equally well done, and that each furrow is raised to a greater height than the middle of the old ridges, so as to allow for the subsiding of that loose earth, the operation will be entirely finished at once, and never again need to be repeated.

In performing this operation, it will always be proper to make the ridges, formed for the purpose of levelling, which go across the old ridges*, as broad as possible; because the deep trench that is thus made in each of the furrows

* I find myself here again at a loss for a term, and am afraid this may occasion some embarrassment to the reader. To avoid this as much as may be, let him observe, that, as the plough is directed to go and return successively directly across the old ridges, the earth on each side of the line first drawn in that direction will be turned towards it, by the ordinary operation of the plough, for a certain breadth, so as to form a division in the field resembling an ordinary ridge. It is this kind of division that I am obliged to call *a ridge that goes across the old ridges, for the purpose of levelling.*

of this new formed ridge across the old ones, are an impediment in the future operations, as well as the height that is accumulated in the middle of each of these ridges, so that the fewer there are of these the better it is. The farmer, therefore, will do well to advert to this in time, and begin by forming a ridge, by always turning the plough to the right hand, till it becomes of such a breadth as makes it very inconvenient to turn longer in that manner; and then, at the distance of twice the breadth of this new formed ridge, from the middle of it, mark off a thurrough for the middle of another ridge, turning round it to the right hand, in the same manner as was done in the former, till it becomes of the same breadth with it; and then turning to the left hand, plough out the interval that was left between the two new formed ridges. By this mode of ploughing, each ridge may be made of forty, or even fifty or sixty yards in breadth, without any great inconvenience; for, although some time will be lost in turning at the ends of these broad ridges, yet, as this operation is only to be once performed in this manner, the advantage that is reaped by having few open furrows, is more than sufficient to counterbalance it. And, in order to moderate the height that would be formed in the middle of each of these great ridges, it will always be proper to mark out the ridges,

ges, and draw the thurrough that is to be the middle of each, some day before you collect all your labourers to level the field ; that you may, without any hurry or loss of labour, clear out a good trench through the middle of each of the old ridges ; as the plough at this time, going and returning nearly in the same track, prevents the labourers from working properly without this precaution.

If these rules are attended to, your field will be at once reduced to a proper level, and the rich earth that formed the surface of the old ridges be still kept upon the surface of your field ; so that the only loss that the possessor of such ground can sustain by this operation, is merely the expense of performing it.

But this expense, I am sensible, will be apt to startle many from attempting it, as it is but too common with people in the country, who are not much in the practice of making accurate calculations, as much to over-rate in their own minds the expense of manual labour, as they under-rate the expense of ploughing, and the other operations performed by their own horses and hired servants. For the satisfaction of those who may never have attempted any operation of this sort, I shall let them know what I have found it to be.

It

It will readily occur to every one, that the expence of performing this operation must vary, according to the height and breadth of the ridges. The breadth, in a particular manner, increases the expence ; because, as the earth has, in that case, to be thrown very far, it tires the labourers so much, that they are not able to do near so much work as if they were narrower. But, on ground where the ridges are so high as that they would require to be *cloven*, or laid from the middle towards the furrows five or six times, and as many times cross harrowed, before they could be brought to a level, by means of these implements alone, I find that ten or eleven men will, in the manner above described, level the ground as fast as one plough can turn it over, if it goes at an ordinary pace. Now, as a man can work during the time of two and a half ordinary double yokings in the day, eleven men in one day will level as much ground as could be ploughed at two yokings and a half of one plough, even where the ridges are as high as they can ever be met with ; and, where the height is more moderate, five or six men would be sufficient to perform the same quantity of work. From which *data* any one who chuses to do it may make a comparison of the expence of performing this operation in either of these two ways, properly adapted to his own particular situation ; for this must necessarily vary very

much in different places, as the expense of labour and other circumstances may be very different.

But, for the satisfaction of such as may wish to avoid the trouble of making this calculation, I shall attempt it in the following manner: Let us suppose, that the price of labour in Scotland varies in different places from six-pence to one shilling, and that the medium price may be fixed at nine-pence per day; and that the hire of a plough, with four horses and two servants, (for so many, in general, will be requisite to labour properly ground in the condition that this is supposed to be in), varies in like manner, from three to five shillings per yoking; and that the medium price of this should be called four shillings; in this case, the comparative expense of levelling, by these two different modes, would be as follows:

Levelling by the Spade.

For wages to eleven labourers one day, at nine-pence each, -	L.	0	8	3
For the hire of a plough $2\frac{1}{2}$ yokings, at four shillings each,		0	10	0
Total expense of one day's work,		0	18	3
Levelling				

Levelling the same by the plough and harrows.

For $2\frac{1}{2}$ yokings of a plough as above, L. 0 10 0

For harrowing ditto, supposed at $\frac{1}{4}$ of the ploughing, 0 2 6

Total for once ploughing, &c. 0 12 6

The same five times more repeated, 3 2 6

Total expense of levelling by plough and harrows, 3 15 0

Total expense of levelling by the spade 0 18 3

Difference, L. 2 16 9

So that the expense of levelling by the plough, is above four times as great as performing that operation by the spade, at the rates above mentioned; which is a difference so very great, as no variation of the rates of labour, from what is supposed above, could in any case nearly compensate.

It will possibly be objected by some, that I here lay the whole expense of the six ploughings and harrowings to the account of levelling; whereas, they ought rather, in a great measure,

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measure, to be considered as a summer-fallow, and charged of consequence to that head; which would reduce the expense of levelling considerably. But, if they consider the matter with due attention, they will find that this plea cannot be admitted. It must be remembered, that each successive ploughing, when performed in this manner, buries a part of the good earth that was meliorated by the former ploughings, and turns up some of the inert earth in the middle of the ridge; which, by the next ploughing, is made to cover another parcel of good earth, and have its place supplied by other earth still more inert than it was: so that, when the whole six ploughings are finished, instead of having the field meliorated as by a fallow, a great part of its surface is covered with that inert earth, which is much worse than the native mold would have been without any fallow at all: And it is thus made so unequal in quality, as to be productive of the very worst consequences, as has been already remarked: So that, instead of having done any service to the field, the whole of these ploughings and harrowings have really rendered it worse than before, and ought therefore to be entirely charged to the account of the levelling, and to no other account whatever; as well as the damage that the ground sustains by this operation, which has not been charged

charged to the account. On the other hand, were we to calculate accurately, the ploughing that accompanies the levelling by the spade ought not, by any means, to be charged to the account of levelling; as it answers every purpose of a fallow in the highest degree: To which purpose the operations with the spade likewise contribute in some measure. On all which accounts, I think it is palpably obvious, that this is not only the most effectual method of levelling ridges, but also the least expensive, and, beyond any degree of comparison, the most profitable to the farmer.

After what has been said, I presume the reader will excuse me, if I take no farther notice of the various machines that have been invented for carrying the earth from the heights into the hollows; as I flatter myself, that he will be satisfied, that, although they were much more perfect than any of them are, and should diminish the expense of the operation of the plough very considerably; yet the inconveniences that result from the use of them, are so many and great, as could never admit of a comparison with that by the spade.

The above is what I deem the very best method that can be practised for levelling ridges; and, as I have frequently performed it with the greatest success, I can recommend it as such from experience. But, on some occasions,
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the situation of the field may be such as to render ploughing it across incommodious; and, in that case, the following method, although less perfect, may be substituted in its stead.

In this method, it is necessary, first to *cleave* out every ridge, so as to leave an open thorough in the middle of it: But, in performing this operation, it will be proper to leave about a yard or so on each side of the old furrow untouched; which will form a pretty deep ditch between each ridge when the whole field is ploughed.—Let labourers be then sent into the field with spades, who shall dig a trench in the open in the middle of each ridge, more or less deep according to the height of the ridge; the earth that is taken out of it, being thrown into the furrow on each side: And, after the whole is cleared out from end to end, let the plough be again set into the field, to turn back a thorough of the upper mold from each side into the new made trench; after which, the diggers begin a-fresh to work in the bottom of this new made thorough; throwing the earth still into the hollow between the old ridges. And, if all this is not sufficient to raise them high enough, let another thorough be turned back into the trench, and another new one dug after it; repeating this alternate ploughing and digging as often as shall be found necessary. And, after the whole is thus brought to a proper

per level, let it be harrowed across, if it cannot be ploughed, to mix the whole as perfectly as may be.

The expense of this operation is nearly the same as the former, but rather greater, and is always less perfectly done; so that, unless where a man is so situated, as not to have it in his power to command a sufficient number of labourers at once to carry on the other method of levelling properly, or is peculiarly confined by some other circumstances, I would always advise the other method to be adopted in preference to it. But this is infinitely better than any of the common methods practised by means of machinery.

By either of these two methods, the farmer has the satisfaction of getting his ground reduced to a proper evenness at once, so as to reap the full benefit of a summer-fallow, or any other operation that he may think proper. But, as the earth below the surface must, for some time, be unequally firm, as has been already showed, it will be necessary to lay it into narrow ridges for some years at first, and keep the furrows perfectly open and clean, to prevent as much as may be the water from stagnating too much among the loose porous earth that fills up the old furrows. With this view, the two-bout ridges, as they are called, such as are commonly made in Essex, which are about two
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and a half feet wide, would be the most eligible, if they could be properly formed by the farmer's ordinary apparatus and servants.— But, if this cannot be by them executed *in the most perfect manner*, it will be much better for him not to attempt it, but content himself with laying his fields into ridges of nine or ten feet broad, or any thing under, that he may incline; which may be in all cases laboured with his ordinary implements in a proper manner, and will sufficiently answer the purpose wanted in the present case.

And here it may not be improper to give young improvers one caution, which may be of use to them in this case, as well as on many other occasions; which is, to adopt that method of labouring, and those kind of implements that seem best adapted to the state of his farm and other circumstances, and to adhere to these, without attempting to adopt others, even where he is convinced that they might in some particular cases be more proper than his own; for nothing brings on a more unperceived, altho' certain expense, than a variety of implements; nor does any thing contribute more effectually to diminish the produce of a farm than imperfect culture, which must ever be the consequence of trying new modes of labouring with implements that are not thoroughly known by those who use them: For, as there is a certain nicety
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in knowing exactly the particular trim of every labouring utensil, that can only be acquired by practice, the best of these, when put into unskilful hands, perform their work in an imperfect manner: And the work performed by a man who is thoroughly acquainted with the implement he uses, even where it is not of the very best construction, will be executed with surprising accuracy and perfection. On these accounts, it ought always to be the study of the farmer, to have as little variety of utensils as possible; and, in his choice of these, he ought to adopt those that are fitted to perform the greatest part of the work that his farm may require, although he may, perhaps, be satisfied, that one or two particular fields might admit of being dressed by implements of a more perfect construction than those he employs, and even at a smaller expense; but, unless he has as much ground in this state as to admit of keeping a particular set of servants constantly to practise that mode of culture, and manage this set of implements alone, he had better stick to that with which his servants are acquainted, and bend his chief endeavours to moderate or correct the principal defects to which these are liable.— Thus, for example, supposing a man should be thoroughly convinced, from the most irrefragable proofs, that the implements and mode of culture usually practised in Essex, were the

the very best and least expensive that could be practised on a soil in such order and situation as is usually met with there, and although he should be able to bring one or two of his own fields into a condition as similar to these as could be imagined, it would, nevertheless, be extremely imprudent in him to get a set of implements from Essex for these few fields, or to endeavour to force his servants to use them, instead of those that they have been accustomed to, and for which they have contracted a sort of partial fondness. For, were we even to suppose that men could be brought to drop their deep rooted prejudices against any innovation in practice, and seriously set themselves in good earnest to learn to handle these unknown implements properly; before they could learn the niceties of practice,—before they began to handle them with any sort of dexterity or ease, the field would be finished, and the implements laid up till another season, when they would be almost as new to begin as at first.—But, if this must be expected, even where the operator seriously wishes to do his best, what may we expect will be the case, if he is altogether indifferent about succeeding in these attempts, or even wishes secretly that they may not turn out to advantage, but that the implements will be allowed to go out of order, and the field be laboured in such an imperfect manner as greatly
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to damage the crop,—make the field suddenly run wild, and thus essentially hurt the interest of his employer? But, if the master, instead of this attempt, had taken care to direct the proper method of labouring it with his ordinary implements, the servant would exert himself to the utmost of his power to perform the work with accuracy:—would consider himself in some measure as a party interested in the success of the crop, and use every effort that he could to insure success.—Anxious about this, and emulous to excel, he weighs with attention every hint that is suggested by the judicious master, and marks the result of every trial of his own; so as in time to be capable of perceiving the effects of many nice peculiarities of practice that could never have occurred to the most acute speculative observer. In this manner, the farmer reaps a full instead of a scanty crop—and is saved from an enormous expense to carpenters and smiths; which, as the judicious Mr. Lisle justly observes, too often prove the ruin of young and sanguine improvers.

The advice that is offered above, is so contrary to the usual practice of gentlemen improvers, and so inconsistent with the ideas that naturally present themselves to speculative farmers, that I am well aware of the bad reception it will meet with from many of these.—I perceive the innumerable arguments that present themselves to their imagination against what

is here said:—I foresee the merriment that it will excite,—the raillery that it will produce, and the many witty things that will be said against the man who dares to advance such an absurd opinion, as that a worse practise should, in any case, be preferred to one that is acknowledged to be better. But, without detaining the sensible reader with answers to these obvious objections, I shall content myself with simply desiring the young improver to look around him, and remark the success of those improvers who have adopted the one or the other of these modes of practice, and leave himself to draw the inference that this will suggest. And, if this has the effect to make him remark circumstances with attention, he will not be long of discovering reasons abundantly cogent for confirming him in the opinion that he must adopt.—

Let it not, however, be understood, as if I meant to dissuade the improving farmer from adopting any other implements of husbandry or modes of culture, than those that have been usually practised in that part of the country where his farm may be situated; for, if these are imperfect, he does well to introduce others of a better sort that may be well fitted to the nature of his soil, and the situation of his fields. But, before he attempts this, let him weigh all matters with a cautious circumspection; and what he has once adopted with judgment, let him adhere

adhere to with unremitting perseverance; and success will in the end crown his endeavours. Or if, in process of time, he so far meliorate his soil, as to render his *whole* farm capable of a more perfect degree of culture than it could formerly admit of, let him, when all circumstances are ready for the change, boldly lay aside his former implements and mode of culture, and at once adopt another that he knows to be better adapted to the circumstances of his farm.—Or, if his farm is extensive, and will admit of two distinct sets of labourers, he may make each of these follow a different mode of culture adapted to the state of the fields they are to manage: But, in no case ought he to allow the same labourers to work with different implements, if it can possibly be avoided.—Almost the utmost latitude that prudence can admit of in this respect, is a greater or lesser degree of weight and strength in different implements, of the same construction, adapted to the different degrees of ruggedness in the different fields; and where there is any considerable difference in the tilth of different fields, this ought always to be practised.

E S S A Y IV.

ON THE

PROPER METHOD

OF

SOWING GRASS SEEDS.



PROPER METHOD

SOWING GRASS SEEDS

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E S S A Y IV.

On the proper METHOD of Sowing GRASS-SEEDS.

Theoretical writers advise that grass-seeds should be sowed without grain—The author, from experience, condemns that practice—Reasons—Method of sowing grass-seeds where the ground is too rich to carry a crop of grain—Autumnal sowing of grass-seeds condemned—Of the different kinds of grain with which grass-seeds may be sowed—Circumstances of importance to make the grass-seeds germinate well—Rich clean ground recommended for sowing grass-seeds on—The farmer will be more abundantly repaid by a rich dressing for grass than almost any other crop.

I Would not have taken any notice of this article here, had it not been to combat an error in practice strongly inculcated by several sensible writers, who seem to have been better acquainted with the theory than with the practice of agriculture; who have repeatedly advised the farmer, with the most zealous solici-

tude, 'Never to sow grafs-seeds with any kind of grain; but, in all cases, to sow it by itself; which,' it is said, 'will always do more than repay the loss that is sustained by the want of a crop of grain; the hay being so much bettered by this practice.'

Imposed upon by their specious reasoning, and the seeming confidence with which it was delivered, I have been induced to try the experiment more than once. And now, if I may be allowed to draw any general conclusion from these experiments, and a long continued and extensive course of practice in this respect, it would be, that even, if we were to have no regard to any other circumstance except the grafs crop alone, it will always be best to sow it with some kind of grain; but, when we consider likewise the loss that the farmer thus sustains for want of a crop of grain, the practice recommended must be looked upon as highly pernicious to the farmer.

When grafs-seeds alone are sowed, (I here speak of clover, rye-grass, and other grafs-seeds, usually sowed for hay), upon a soil in tolerable good order, as they make but small progress at first, a great number of small annual weeds are allowed to rush up, which, quickly acquiring strength, fill up the whole ground so much, as to be in great danger of choking the grafs entirely; or, if the soil is not overstocked with
weeds,

weeds, the drought of the summer makes such an impression on the open porous ground, thus destitute of plants to attract moisture to it, that the tender plants of grass are in great danger of being scorched and burnt up: Whereas, when the grass-seeds are sowed with any kind of grain, it quickly rushes up in abundance, and prevents the growth of annual weeds, while its broad leaves shade the tender plants of grass from the direct rays of the sun, and preserve the earth in a proper degree of moisture, so as to nurse up the tender grass in the most kindly manner that could be desired. And, as the leaves of the corn decay towards the end of summer, the grass gets then as much air as is necessary, (unless in the case after mentioned) and continues to vegetate with a sufficient degree of vigour, till the grain is cut down; so as to be usually in a healthier and more flourishing state at that time than if it had been sowed alone; and will, in general, be afterwards much freer from natural grasses and other perennial weeds.

But, although ground can seldom be too rich for carrying a crop of grass, yet it may be often so rich as to be improper for producing an advantageous crop of grain. And as it may sometimes happen that we may have occasion to lay a field down with grass-seeds when it is in this state, it would, on this occasion, be improper

for the farmer to be determined to get a crop of grain, as he would run a great risk of losing both crops, by the lodging of the corn before harvest. In this case, it is prudent in him to forego the hope of a crop of grain, but not to omit sowing the seeds of some kind of grain with his grass-seeds. This should be scattered thinly over the field, and will help to bring up the grass-seeds in a kindly manner; and if the season proves very dry, he may thus sometimes reap a very great crop. But, if the season is rainy, or if his crop, from any other cause, is too luxuriant, whenever he sees it begin to lodge, and be in danger of choaking his grass, he ought to cut it immediately, and employ the whole as a green fodder for his cows or other cattle. The extraordinary quantity of provender procured in this way, will be more than sufficient to indemnify him for the price of the seed of the grain; as he will have two full crops of succulent green fodder in one season, which will be about three times the quantity that he would have had, if the grass-seeds had been sowed alone.

This is the best method for laying down very rich land to grass that I have ever seen practised.

As to such ground as is in a proper condition for carrying a moderate crop of grain, I am entirely satisfied, not only from the reasoning above,

bove, but also from repeated experiment, that the crop of grafs is at least *equally* good when it has been sowed with grain, and the crop allowed to ripen, as when it has been sowed without any crop at all; so that farmers do well to continue their common practice in this respect, however much it may be opposed or decried by theoretical writers.

As to autumnal sowing of grafs-seeds, I have found, that it is much more precarious than the vernal, and therefore would never recommend it but in cases of great necessity; when a lesser evil ought to be preferred to a greater.

With regard to the kinds of grain with which grafs-seeds may be sowed:—Barley is, in general, the best, as the ground is usually well prepared for that crop, and the season of sowing it answers very well for grafs-seeds. Oats are not so proper, in general; although, when the ground is very well prepared for them, the grafs will succeed extremely well; but it ought never to be sowed with wheat, excepting in cases of necessity, as it oftener fails in this way than in any other; although I have known it sometimes to succeed extremely well.

The circumstances necessary to be attended to for making the feeds vegetate kindly when sowed, are, in general, so obvious, as to be easily distinguished by any one who attentively considers the subject. The seeds are, for the
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most part, small, and therefore require the mold to be pretty fine, that they may not be covered too deep by falling below, or be scorched up by lying above great clods.—Like every other seed, they require a due degree of moisture to cause them to vegetate, and therefore ought never to be left exposed to the rays of the sun, without being covered; as, unless a tract of rainy weather comes immediately after sowing, many of the seeds will be destroyed. On this account, it is always necessary to harrow the ground immediately after sowing with a light close toothed harrow, which should be kept for that purpose; and sometimes a gentle rolling is of use after that, especially upon light spongy ground: But no one circumstance so effectually insures the vegetating of these small seeds, as sowing them as soon as possible after the ground is ploughed; as the moderate moisture that new turned up ground always has when it is in good order, seems to be more peculiarly fitted for promoting the vegetation of every kind of seed, than that which may arise from any other cause whatever. On which account, every industrious farmer will take care to prevent, as much as possible, the withering of the ground after ploughing, so as not to lose the benefit of this circumstance.

Before I quit this subject, it may not perhaps be improper to observe, that the farmer is more
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abundantly repaid for an extraordinary dressing as a preparation for a crop of grafs, than for almost any other crop that he can sow ; and that, of consequence, it is always good œconomy to lay down rich, and not poor ground, to grafs. It is likewise of the utmost consequence to have the ground as free as possible from perennial weeds; so that it ought not only to be rich, but clean also, if you wish to have a very fine crop of grafs. This I the rather take notice of here, because I know that it is a practice pretty general in many parts of the kingdom, to lay only such fields into grafs as are in such bad order as to carry very poor crops of grain, without any sort of preparation whatever ; the bad œconomy of which practice they would soon be convinced of, if they would only be persuaded, for once, to try one directly opposite to it.

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 carry very poor crops of grain, without any
 sort of preparation whatever; the bad economy
 of which practice they would soon be convinced
 if they would only be persuaded, for
 once, to try one of the following experiments.

1. To sow the seed in the autumn, and to
 cover it with a layer of straw, or a layer of
 dung, or a layer of any other substance, which
 will keep the seed warm, and prevent it from
 being killed by frost, or by any other
 accident. 2. To sow the seed in the
 spring, and to cover it with a layer of straw,
 or a layer of dung, or a layer of any other
 substance, which will keep the seed warm,
 and prevent it from being killed by frost,
 or by any other accident. 3. To sow the
 seed in the autumn, and to cover it with a
 layer of straw, or a layer of dung, or a
 layer of any other substance, which will
 keep the seed warm, and prevent it from
 being killed by frost, or by any other
 accident. 4. To sow the seed in the
 spring, and to cover it with a layer of straw,
 or a layer of dung, or a layer of any other
 substance, which will keep the seed warm,
 and prevent it from being killed by frost,
 or by any other accident.

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E S S A Y V.

ON HAY-MAKING.



E S S A Y V.

ON HAY-MAKING.

Hay not to be allowed to lie in the swathe after it is cut.—A particular method of making hay described, that has been long practised by the author with success.—Advantages attending this method of hay-making.—Hay much damaged by a very slight degree of moisture after it is cut.—Cautions to be attended to in this method of winning hay.—It is, in a particular manner, recommended to those who intend to save rye-grass seed,

BEFORE artificial grasses were introduced into this island, hay-making was a very tedious and troublesome operation. But, as the grasses now usually cultivated for yielding hay are not so soft and succulent as the natural meadow-grasses, in general, we have it in our power greatly to shorten that operation, and, at the same time, keep our hay much sweeter than it would be if treated after the old method. For the sake, therefore, of such as may not be well acquainted with the best method
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of making hay from artificial grasses, (I chiefly mean rye-grass and clover) I shall here subjoin an account of a very simple mode of practice in this respect, that I have followed for many years with the greatest success.

Instead of allowing the hay to lie, as usual in most places, for some days in the swathe after it is cut, and afterwards alternately putting it up into cocks, and spreading it out, and tending it in the sun, which tends greatly to bleach the hay,—exhales its natural juices, and subjects it very much to the danger of getting rain, and thus runs a great risk of being made good for little, I make it a general rule, if possible, never to cut hay but when the grass is quite dry; and then make the gatherers follow close upon the cutters,—putting it up immediately into small cocks, about three feet high each, when new put up, and of as small a diameter as they can be made to stand with; always giving each of them a slight kind of thatching, by drawing a few handfuls of the hay from the bottom of the cock all around, and laying it lightly upon the top, with one of the ends hanging downward. This is done with the utmost ease and expedition; and, when it is once in that state, I consider my hay as, in a great measure, out of danger. For, unless a violent wind should rise immediately after the cocks are put up, so as to overturn them, nothing else can hurt the hay;

hay; as I have often experienced that no rain, however violent, ever penetrates into these cocks but for a very little way. And, if they are dry put up, they never sit together so closely as to heat; although they acquire, in a day or two, such a degree of firmness, as to be in no danger of being overturned by wind after that time, unless it blows a hurricane.

In these cocks, I allow the hay to remain until, by inspection, I judge that it will keep in pretty large tramp-cocks, (which is usually in one or two weeks, according as the weather is more or less favourable), when two men, each with a long pronged pitchfork, lift up one of these small cocks between them with the greatest ease, and carry them one after another, to the place where the tramp-cock is to be built*;

* If the hay is to be carried to any considerable distance, this part of the labour may be greatly abridged, by causing the carriers to take two long sticks, of a sufficient strength, and, having laid them down by the small cocks parallel to one another, at the distance of one and a half, or two feet asunder; let them lift three or four cocks, one after another, and place them carefully above the sticks, and then carry them all together, as if upon a hand-barrow, to the place where the large rick is to be built.

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And in this manner they proceed over the field till the whole is finished.

The advantages that attend this method of making hay are, that it greatly abridges the labour ; as it does not require above the one half of the work that is necessary in the old method of turning and tedding it ;—that it allows the hay to continue almost as green as when it is cut, and preserves its natural juices in the greatest perfection. For, unless it be the little that is exposed to the sun and air upon the surface of the cocks, which is no more bleached than every straw of hay saved in the ordinary way, the whole is dried in the most slow and equal manner that could be desired. And, *lastly*, that it is thus, in a great measure, secured from almost the possibility of being damaged by rain.

This last circumstance deserves to be much more attended to by the farmer than it usually is at present ; as I have seen few who are sufficiently aware of the loss that the quality of their hay sustains by receiving a slight shower after it is cut, and before it is gathered ; the generality of farmers seeming to be very well satisfied if they get in their hay without being absolutely rotted ; never paying the least attention to its having been several times thoroughly wetted while the hay was making. But, if these gentlemen will take the trouble at any time to compare

pare any parcel of hay that has been made perfectly dry, with another parcel, from the same field, that has received a shower while in the swathe, or even a copious dew, they will soon be sensible of a very manifest difference between them; nor will their horses or cattle ever commit a mistake in chusing between the two*.

Let it be particularly remarked, that, in this manner of making hay, great care must be taken that it be dry when first put into the cocks; for, if it is in the least degree wet at that time, it will turn instantly mouldy, and sit together, so as to become totally impervious to the air, and will never afterwards become dry, till it is spread out to the sun. For this reason, if at any time, during a course of good settled wea-

* I have met with several gentlemen in Scotland who have complained, that they found it impossible ever to get their clover hay to look like that they met with in London,—as the leaves were always of a dark tobacco-like colour, and parted from the stalks with the slightest handling, instead of being of a dark olive green, and soft and pliable to the touch, and not readily separable from the stalks. This difference is entirely occasioned by the winning: For, if clover is allowed to be wetted after it is cut, it will infallibly be brown and brittle; but, if it has been carefully preserved from moisture, and slowly made into hay, it is tough and pliable, and retains its greenness in some degree.

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ther, you should begin to cut in the morning, before the dew is off the grafs, keep back the gatherers till the dew is evaporated, allowing that which was first cut to lie till it is dry before it is cocked. In this case, you will almost always find, that the uncut grafs will dry sooner than that which has been cut when wet; and, therefore, the gatherers may always begin to put up that which is fresh cut before the other; which will usually require two or three hours to dry after the new cut hay may be cocked.

And if at any time, in case of necessity, you should be obliged to cut your hay before it is dry, the same rule must be observed, always to allow it to remain in the swathe till it is quite dry: But, as there is always a great risk of being long in getting it up, and as it never, in this case, *wins* * so kindly as if it had been dry cut, the farmer ought to endeavour, if possible, in all cases, to cut his hay only when dry, even if it should cost him some additional expense to the cutters, by keeping them employed at any other work, or even allowing them to remain idle, if the weather should be variable or rainy.

* By winning hay, is meant the operation by which it is brought from the succulent state of *grafs* to that of a dry fodder.

But

But if there is a great proportion of clover, and the weather should chance to be close and calm at the time, it may, on some occasions, be necessary to open these cocks a little, to admit some fresh air into them; in which case, after they have stood a day or two, it may be of great use to turn these cocks, and open them up a little, which ought to be done in the driest time of the day; the operator taking that part of each cock which was the top, and with it forming the base of a new one, so that the part which was most exposed to the air becomes excluded from it, and that which was undermost comes to be placed upon the top, so as to make it all dry as equally as possible.

If the hay has not been damp when it was first put up, the cock may be immediately finished out at once; but, if it is at all wet, it will be of great use to turn over only a little of the top of the cock at first, and, leaving it in that state to dry a little, proceed to another, and a third, and fourth, &c. treating each in the same way; going on in that manner, till you find that the inside of the first opened cock is sufficiently dried, when it will be proper to return to it, turning over a little more of it, till you come to what is still damp, when you leave it and proceed to another, and so on round the whole; always returning afresh, till the cocks are entirely finished. This is the best way of

saving your hay, if you have been under the necessity of cutting it while damp; but it is always best to guard against this inconvenience, if possible.

Although I am convinced that this method of making hay is, in all cases, the best that ever I have heard of, yet it is in a more especial manner worthy of being recommended to such as intend to save the seed of rye-grass; as, in that case, it is attended with many and great advantages. Every one, who is in the least acquainted with this subject, knows, that this kind of grass is so very apt to shed its seeds, that, if the hay is allowed to lie in the swathe till it is dry, a very great proportion of the seed will inevitably be lost by the necessary handling when it is gathered, however carefully this may be done.

To avoid this inconvenience, I have known several farmers who have thought it worth the expense of causing it to be gathered immediately after the cutters, and then bound up into sheaves, and put up into stooks (shocks) like corn, till it is thoroughly dried; for, by being in this state more easily lifted than when it is quite loose, less of it will be lost in carrying to be threshed.

But, not to mention the expense necessarily attending this practice, it is likewise attended with another inconvenience, which subjects
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the farmer, on many occasions, to a greater loss than he would sustain by handling in the ordinary way. For, if it should chance to come a tract of rainy weather when it is in the stook, the whole of the hay is at once drenched with water; and, if it continues wet for any length of time, the seed quickly loses its colour, and becomes musty, and even begins to grow before it can be threshed out; so that both the hay and the seed will be totally, or in a great measure lost.

But, in the mode of practice here recommended, all the benefit that could be expected from this procedure is fully obtained, and the inconveniencies attending it entirely avoided. For, by putting it into the cocks as soon as it is cut, while the seed adheres more firmly to the hay than after it is dry, little is shaken off by the gathering; and still less is lost in carrying it to the place where it is to be threshed (which ought to be in the field at the place where a tramp-cock is intended) in this way, than when bound up into sheaves. And, as these cocks resist the rain perfectly well, the seed or hay are in no danger of being spoiled by rainy weather, if it should chance to come after they are once put up. And, besides, as the hay is not thus so much exposed to the weather, it is not near so much spoiled in its colour, or dried in the *wining*, as it is in the usual method. On

all which accounts, I deem it by far the most eligible method of saving this kind of grass-feed.

The truth of these remarks I had an opportunity of experiencing this very year 1772; the latter part of the hay-season having proved extremely rainy, insomuch that a very good and experienced husbandman of my acquaintance, who took the former method of saving his grass-feeds, had them so much spoiled by the rain, and his hay, at the same time, so much damaged by it, that he was ashamed to offer either of them to sale; whereas mine, which were treated in the manner I now recommend, were both as sweet and wholesome as any good judge could wish them to be: My hay, in particular, being as green and succulent as any hay got in the usual method is, even when it is not threshed.

ESSAY VI.

ON

QUICK-LIME.

1. The first group of people who are interested in the results of the study are the researchers themselves. They want to know if the study was successful in achieving its goals and if the data collected is reliable and valid. They also want to know if the study has contributed to the field of research and if it has provided any new insights or findings.

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O U I C K - J I M E.

ADVERTISEMENT.

THE nature of the subject discussed in the following Essay, necessarily required that it should be treated in a more scientific manner than any of the others. The Author has endeavoured to render it as perspicuous as possible; but is afraid that, to those who may never have been versant in studies of this sort, it may still, in some places, appear a little obstruse.—On this occasion, he hopes to meet with the indulgence of those, who think no exertion of mind improperly bestowed when it is in the pursuit of useful knowledge.—Others, who do not care to engage in intricate discussions of any sort, he would advise to pass over this Essay entirely;—or, at least, the first part of it. The reasons for what is advanced in the second part will not indeed be, in that case, so clearly seen; but the practical farmer, if not thoroughly instructed by that, may at least be directed to what he ought to do.

ESSAY VI.

ON QUICK-LIME.

QUICK-LIME is a *calx*, or a very fine powder, obtained by burning marble, chalk, or lime-stone, and afterwards throwing water upon it.

This powder, when newly burnt, is soluble * in water;—is capable of being formed into a firm cement, if properly mixed up with water, and is possessed of many other pe-

* Capable of being dissolved.

To avoid disagreeable circumlocution, I shall be obliged, in this Essay, to employ some technical terms not commonly understood;—but shall explain their meaning as I go along.

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culiar qualities that is unnecessary here to enumerate.

But, if this powder has been exposed to the influence of the air for some time, it is found to be no longer capable of being dissolved in water;—it has become incapable of being formed into a cement, and has lost many of the other peculiar qualities for which it was at first remarkable.

In common language, this powder is usually distinguished by the name of LIME simply. But in the language of philosophic precision, it is called QUICK-LIME, so long as it remains soluble in water, and capable of being used as a cement. After it loses these properties, it is distinguished by the name of EFFETE lime.

In either of these states, it is employed by the farmer as a manure. And, as it is the manure of most universal utility that has yet been discovered, its nature and qualities deserve to be very particularly investigated.

The design of this Essay is to point out some of the peculiarities that constitute the excellence of this substance as a manure, and as a cement. And, as what may be said of it, as a manure, will
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be better understood after its nature, as a cement, has been explained, it will be necessary to consider it first in that point of view.

PART

is better understood after its nature, as a cement has been explained, it will be necessary to consider it first in that point of view, and then in that of a cement.

The first point to be considered is the nature of the substance, and the second is the manner in which it is used.

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PART FIRST.

Of Quick-lime as a Cement.

§ 1.

IF lime-stone, or marble, be exposed to the action of a pretty intense fire for a sufficient length of time, its colour is altered, and its weight considerably diminished; but it retains its former figure and dimensions.

In this state of burnt stone, it is in many places distinguished by the name of *lime-shells*, or *shell-lime*, or simply *shells*.

§ 2.

If water be thrown upon these *lime-shells*, a considerable heat is in a short time generated; the burnt stones begin to crack and fall asunder, and the mass encreases in bulk as it gradually crumbles down, or *falls*, as it is more commonly

ly said, into a fine powder ; which is always of a white colour, whatever was the colour of the stone before calcination *.

This powder is called *slacked lime*, or simply *lime*; and the operation that reduces it from *shells* to this state, is called *slaking*.

§ 3.

If this powder is intimately mixed with as much water as reduces it to the consistence of a thin paste, and afterwards dried, it concretes into one coherent mass, which adheres to stones, or other unpolished bodies, very firmly; and thus it becomes a proper cement for building walls of any sort.

After this paste has been once fully dried, it becomes indissoluble in water, so as never to be softened by the moisture of the air; on which account it greatly exceeds clay, or any other cement that can be easily obtained.

This cement, when composed for building walls, is called *mortar*. When intended to be applied only as a smooth coating upon the surface of any place, without being mixed with

* *Calcination* is the operation by which any solid compact body is, by means of fire, reduced from its former coherent state, to that of a dry incoherent powder, which is called a *calx*.

stones, it is called in this country simply *plaster*.

§ 4.

It has been found by experience, that the cement made of lime that had been obtained from a lime-stone that consisted of pure *calcareous* * earth alone, without any proportion of sand, never attained any great degree of hardness, but remained a soft crumbly mass, that might be easily broke down by any small force applied to it.

And, on the contrary, if the original lime-stone contained a very large proportion of sand, the cement made of it alone was a much harder, firmer, and more durable substance.

And, as it was discovered that the purest lime might be rendered a very firm cement by the addition of a due proportion of clean hard sand, the practice of mixing sand with lime, when intended for mortar, came to prevail very universally.—The oldest lime-built walls that are now to be found, clearly show that this practice

* *Calcareous* is a general term denoting all those substances that consist of the matter of which lime may be made, in whatever state it may be found—whether alone—or mixed with other substances, that prevent it from being reduced to powder after calcination.

practice has been adopted before these were built.

But it still remains a *desideratum*, to ascertain the due proportion of sand; as authors, as well as practical masons, differ very much from one another as to this particular.

They likewise differ very much in their directions about the mode of mixing the materials, and of applying the cement;—some modern authors, especially, attributing amazing effects to a small variation of these particulars, while others deny that these circumstances have any sensible effect on the durability or firmness of the cement.

These different and contradictory opinions seem to arise from an imperfect knowledge of the nature of quick lime, and the variations it may admit of: For these variations are so very great, as to render it impossible to give any general rules that can possibly apply in all cases. It, therefore, behoves those who wish to attain any consistency of knowledge on this subject, to endeavour, first to ascertain the circumstances that render calcareous substances capable of becoming a cement *at all*, and then to trace the several changes that may be produced upon it by other extraneous causes.

This I shall endeavour briefly to do.

§ 5.

Lime-stone and marble are nothing else than a calcareous matter *chrySTALLIZED* *, and assume different appearances according to accidental circumstances that have occurred at the time of their original formation.

1st, The more perfect these chrySTALS are, the *harder* and more compact will the stone be that consists of them.

2d, The smaller the proportion of extraneous matter that is entangled among these chrySTALS, the *purser* and finer will the lime be that is made from the stone of which they consist.

From a variation in one or other of these two particulars, arise all the varieties of calcareous matter, that can be converted into lime; which varieties may be distinguished from one another by the following particulars.

* Saline substances, when dissolved in water, and put into proper circumstances for that purpose, separate from the water, and *shoot* into regular figures, which assume different forms, and are more or less transparent according to the different nature of the salt, as nitre, alum, &c. These regular transparent bodies are properly called *chrySTALS*.—Hence every body in nature that assumes a form and appearance similar to these, and is produced in the same manner, is said to be *chrySTALLIZED*.

1st, When the calcareous matter is *pure*, and perfectly chrystallized; when it assumes a clear and somewhat transparent appearance, and is found in regular *strata*, without many fissures, it is then called *marble*.

2d, When the calcareous matter is *pure*, but the chrystallization less perfect, tho' in regular *strata*, it still obtains the name of marble; but, as it is more opaque, and less compact than the former, it is reckoned less valuable, and coarser.

3d, When the calcareous matter is still pretty pure, but hastily concreted into an uniform mass, without having been in a state that permitted it to chrystallize, or to subside into regular *strata*, it is called *chalk*; which, when reduced to a powder, without calcination, is called *whitening*.

4th, When the chrystals are tolerably perfect, but have had a considerable proportion of sand entangled among them, it is no longer called marble, but *lime-stone*. And this is more or less *pure*, or affords a richer or poorer lime, as it contains a greater or smaller proportion of calcareous matter; and is more or less *hard* according to the degree of perfection of the chrystals.

Even the purest calcareous matter perfectly chrystallized, is called lime-stone, and not marble,

marble, when it consists of small pieces that have not been concreted into regular strata.

5th, When the calcareous matter is perfectly pure, and shot into smaller chrystals of a transparent whiteness, it is called *sparr*,—and in other circumstances, *stalactites*.

6th, When the calcareous matter has been formed by nature as a covering for animals; it is called *shell*; in which class may be included *corals* and *corallines*.

These are all the substances that have hitherto been employed for making lime. The other varieties of calcareous matter,—(that I may bring them all under one view, and point out their essential distinctions,) are as follow :

7th, When the calcareous matter, while in its fluid state, has been absorbed into a bed of clayey matter, and with it concreted into an uniform, compact, unchrystallized mass, it has been denominated *marle*,—which is more or less *pure*, according to the proportion of calcareous matter it contains, and more or less *hard*, according to the nature of the clay, and the proportion of sand that may have been mixed with it. And,

8th, When *shells*, by the lapse of time, and by long macerating in water, have lost the animal gluten that cemented them, and are

crumbled down to a fine whitish powder, they are denominated *shell-marle*.

It would be a curious disquisition to enquire how these masses of calcareous matter were originally formed:—How they were reduced to a state that rendered them soluble in water, which must have been the case before they could admit of being chrystallized:—What were the circumstances that contributed to render some of these chrystals so much more perfect than others, &c. &c.—But these disquisitions, however curious they might be, are here omitted, as not absolutely necessary for the elucidation of our subject. The explanation of the nature of the different calcareous matters above given was necessary; as, without a knowledge of these, it would have been impossible to have explained, in a satisfactory manner, the way in which these substances are more or less fitted to be employed as a cement, or a manure.

To avoid unnecessary repetitions, the reader is desired to observe, that, for the future, I shall mention all matters that can be converted into quick-lime under the name of *lime-stone*, whether they be in the form of marble, chalk, or common lime-stone; distinguishing either of these when it may become necessary.

§ 6.

Lime-stone in the state we find it is always a compound substance.—In its purest state, it consists of a calcareous earth, united with a considerable proportion of water. For, saline matters, when chrystallized, always contain water.

Limestone likewise contains another substance, the nature of which will be afterwards explained.

When lime-stone has been exposed for a sufficient length of time to the action of a sufficiently intense fire, the whole of the water it contained is evaporated: So that lime-shells are always lighter than the stone of which they are made, by the whole weight, at least, of the water the chrystals contained.

And, as perfect chrystals always contain a much larger proportion of water than those that are less perfect, it follows that, of two kinds of limestone of equal *purity*, that which is hardest and most transparent, will lose a greater proportion of its weight in calcination, than that which is softer and more opaque.—Hence *marble* loses more weight by burning than *chalk* *.

Again,

* Such readers as are totally unacquainted with the circumstances that are necessary to the formation of chrystals

Again,—as sand loses nothing of its weight by calcination, it likewise follows, that, in two kinds

chrystals in general, will probably be at a loss easily to comprehend the chain of argumentation followed here and in some other parts of this Essay. The following explanation will make it more intelligible.

As saline matters, properly so called, are more easily chrySTALLIZED by art than any others, it will be best to take our illustrations from that class of bodies.

It is a property of saline bodies, that they may all be dissolved in water.

They may also be separated from that water, and obtained in a dry form; but they assume very different appearances, according to the nature of the process that is followed for separating them from that water.

If a watery solution of any salt be suddenly evaporated by means of fire, there remains behind a white substance, sometimes slightly coherent, as in pearl-ashes, &c. and sometimes it falls into a powdery calx, as in evaporating a solution of Glauber's salts, alum, &c.

But, if the water be gently evaporated by a moderate heat—before it becomes a dry powder, the salt quits the water, and shoots out into regular figures of a transparent glassy like appearance,—which have obtained the name of chrystals.

These chrystals vary in figure, hardness, &c. according to the nature of the salts of which they are composed.

But they all agree in one respect, that they contain a considerable proportion of water united with the saline matter.—Some kinds of salt absorb a very large proportion of water in this way.—ChrySTALLIZED Glauber's salts contain two thirds of their weight of water.—Common salt does not contain near such a large proportion.

Hence

kinds of lime-stone equally firm and well chrySTALLIZED, the *purest*, or that which contains the

Hence it happens that no chrySTALS of any kind of salt can possibly be formed, unless these salts have been perfectly dissolved in water.

And the perfection and transparency of these chrySTALS depends entirely on their being allowed to shoot leisurely, in that degree of heat that is best adapted to the nature of each particular kind of salt.

For it often happens, that water can be made to dissolve a much larger proportion of salt when it is hot than when it is cold; so that, if a solution of these kinds of salts is continued in a considerable heat, it will still remain fluid, even after it has less water than would be necessary for forming the chrySTALS.—In which case, if it is taken from the fire, and allowed to cool, it suddenly *concretes* into a solid opaque kind of mass between a chrySTAL and a *calx*—as may easily be experienced, by melting chrySTALLIZED Glauber's salt in a fire shovel, and allowing it to cool before it is entirely evaporated to dryness.

The same circumstances contribute to the formation of calcareous matters into chrySTALS,—and may be easily applied by the reader.—Lime is the *calx* produced by evaporating the chrySTALS to dryness;—and it only differs from other *saline calces* in this respect, that *they* always retain the quality of being soluble in water, and may be converted into a liquid mass, and again chrySTALLIZED, whenever that is administered to them;—whereas *it* loses that quality in a short time; and, if it has not been dissolved and again chrySTALLIZED in that short space, it must ever remain unalterably in the state it chanced to be in when it lost its saline quality.—Hence it appears, in all the different stages of more or less perfect chrySTALLIZATION, from the most transparent spar, or marble, to the most opaque chalk,—from the hardness of a flint to the looseness of an almost incoherent powder.

greatest proportion of calcareous matter, will lose, in calcination, the greatest proportion of weight.

From these facts, it appears, that no rule can be given for ascertaining the proportion of weight *that* lime-stone loses by calcination. It must vary in all possible degrees, according to circumstances.

§ 7.

Lime-stone, besides the ingredients above mentioned, contains a considerable proportion of another fluid that enters into its composition, and greatly alters its chemical qualities, to which philosophers have given the name of *fixed air*. This is also disentangled from the stone, and dispersed, in the act of calcination; as has been demonstrated by the very ingenious Dr. Black of Edinburgh, to whose most satisfactory essay on this subject, in the *Physical and Literary Essays*, vol. 2d, I refer the curious reader.

When lime-stone is thus deprived of its *fixed air*, it acquires many of the properties of saline bodies. It is in consequence of this that it then becomes capable of being dissolved in water,—is extremely acrid,—and acts most powerfully
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on many bodies upon which it has no sensible effect, while in the state of lime-stone.

On these accounts, chemists having given it the appellation of *caustic*, when in this state, in contradistinction to its ordinary state before calcination, or after it is again united with its fixed air; when it is said to be in its *mild* state.

Hence, then, the phrase *mild*, when applied to calcareous earth, denotes that it is *then* united with its fixed air, which may be said equally of it before calcination, when it is called lime-stone, or after calcination, when it is denominated *effete* lime: And *caustic* calcareous earth is a phrase exactly synonymous with *quick-lime*, in its strict and philosophical acceptation;—that is, calcareous earth perfectly detached, in a chemical sense, from every other substance.

§ 8.

But, although it is possible, by art, to free lime-stone from its water and air, and reduce it to the state of an unmixed acrid saline *calx*;—yet no art can keep it long in that state, as it has an irresistible propensity to unite itself again to these substances.

If water is poured upon the stone immediately after calcination, it has been already said, that it pervades every part of the stone, each particle

particle of the lime seems greedily to seize some portion of the water, with which it instantly and intimately unites. In the act of union, a considerable heat is generated, and, in a short time, its whole particles are perfectly detached from one another, so as to fall down in the form of a fine, white, and seemingly dry powder, notwithstanding the large quantity of water that is thus united with it*.

If lime-shells be exposed to the influence of the air, without throwing water upon them, they quickly attract moisture from thence, which slowly, and without any sensible heat, flakes the lime-shells, and reduces them to powder.

Still, however, the lime retains its *caustic* quality, even after its partial union with the water: But it as irresistibly, though more slowly, continues to absorb the *air* of which it had been deprived, and, without intermission, perpetually tends towards that *mild* state that seems to be natural to it.

§ 9.

* The quantity of water contained in dry flaked lime is much greater than any one could possibly imagine.—By experiment, I find, that *pure* lime *perfectly calcined*, requires, *at least*, its own weight of water, before it can be reduced to a powder. By the heat generated in the operation, about one tenth of that water is evaporated,—so that the *driest* flaked lime, if pure, consists of about equal parts of calcareous earth and water.—Such as is flaked to the *ordinary degree*, contains a great deal more water than is here mentioned.

§ 9.

If water is poured upon flaked lime, in large quantities, that water dissolves a certain portion of the saline *calx*, which forms the solution called *lime-water*, that has been much prized as a medicine by some physicians.

But the lime has hardly had time to be dissolved by the water, before the calcareous earth absorbs a proportion of its fixed air from the water itself, and the surrounding atmosphere; with which it forcibly unites, and immediately again becomes *mild* calcareous earth, or, if you will, lime-stone. And, as it is not, *in this state*, soluble in water, it immediately separates from it, and forms a thin film of chrySTALLIZED lime-stone on the surface of the water.

In this way all the lime is, in a short time, separated from the lime-water, and it quickly loses all those qualities for which it was remarkable; becoming pure and simple water again, unless some caustic lime be allowed to remain at the bottom of the vessel, upon which the water may again act, after what it had formerly dissolved had left it.

§ 10.

§ 10.

It is, by a process somewhat similar to the former, that calcareous *stalactites* are formed in caverns under the earth, depending from the roof in the form of very large icicles and other grotesque figures, that afford matter of admiration and astonishment to the curious who visit these subterranean caverns. It is but seldom that we are able to give such a distinct account of the operations of nature as in the present case.

These *stalactites* are always formed by water dropping from the roof. This water, in these cases, is always slightly impregnated with caustic calcareous matter, which it meets with in the bowels of the earth, and dissolves.—By what process that calcareous matter is there rendered *caustic*, remains as yet to be explained, and affords a subject well worthy the investigation of the curious.

This natural lime-water, when it comes to the roof of the cavern, hangs for some time in the form of a drop, till at length so much water is accumulated there, as by its natural gravity overcomes the power of cohesion, and makes it fall to the ground. But it is no sooner fallen, than it is again succeeded
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by another,—and another,—and so on, *in infinitum*.

While these drops remain suspended from the roof, the calcareous matter contained in them greedily attracts the air all around the surface of the drop, and, before it falls, a small part of it is reduced to a *mild* state,—leaves the water with which it was formerly united, and adheres firmly to the roof; which, in time, accumulates so much solid matter as to form a sort of pap depending directly downwards.

After this pap is formed, each drop, as it descends, flows from its root towards its point, so as to be diffused in a thin stream over its whole surface. In this situation, the water is so much exposed to the action of the air in its descent, that a part of the calcareous matter is rendered *mild*, and is left adhering to the former, so as to encrease its diameter towards the root, while a part flows forward to the point, and adds to its length, in the same manner as it first began to be formed.

In this manner these tangles continue to encrease in size so long as they are suffered to remain,—and, as ought to be expected from the above induction, there is always a small hole through the heart of each of them.

The tangles under bridges, and other artificial arches through which water is permitted

mitted to percolate, are formed exactly in the same manner, though usually they are less perfectly chrystallized.

All sorts of calcareous *spars* owe their origin to a similar cause.

While these natural *stalactites* are of a small size, they will continue to be regularly formed, and retain the figure of icicles;—because the water, as it oozes out, will be sufficient to surround the whole of the pap, and augment it equally on every side. But, in time, these will become so large, as to cause the water to flow down only on one side, after which the figure will become distorted and irregular. Two or more will sometimes unite into one; and, in the course of ages, an infinite diversity of fantastic forms will gradually be produced, which may exhibit, on many occasions, figures of stupendous magnificence.

§ II.

The operations of nature are so simple, that, when we once get a glimpse of the manner in which they are effected in one instance, it is easy to extend our observations in a satisfactory manner to others of a similar nature. When we once perceive the manner in which calcareous *stalactites* are formed, it is easy to comprehend the way in which more regular strata of calcareous

ous substances have been produced. The same cavern that produces the one will always afford examples of the other.

The drop of lime-water that falls from the roof of the cavern, although it has lost some of the calcareous matter with which it was impregnated, still retains a part. When it reaches the ground, it either remains stagnant so as to form a pool, or flows over a smooth surface. In either of these cases, it will be allowed time to absorb some more of its air; and a part, or the whole, of the calcareous earth will be rendered *mild*, and remain in a firm chrystallized solid cake of marble.

If the stream is considerable, the sheet of calcareous matter may be extended to a great distance, thinly spread over a large declivity, as the water flows in its course,—till at last the whole cavity may be filled with a regular stratum of lime-stone—or marble.

In this manner, within the memory of man, have huge rocks of marble been formed near Matlock in Derbyshire,—which furnish matter of astonishment to those numerous travellers who flock to see this uncommon phaenomenon. —It is seldom that nature's operations are so rapid as in this instance.—But there is no room to doubt, that all the strata of calcareous matter in the world have been formed by a process exactly similar to this.

When

When the drops are smaller, so as not to be sufficient to form a large stream, but still to flow over a small part of the surface, irregular swelling cakes of lime-stone are produced.— When smaller still, they rise up into high prominences, with roundish heads,—sometimes resembling collyflower, and sometimes brocoly heads.

If a current of air hastily promotes the evaporation of the water, the chrySTALLIZATION will be less perfect. But enough has already been said to illustrate the subject I have undertaken.

I now return from the operations of nature to those of art.

§ 12.

If slaked lime be exposed to the air for any length of time, in the form of a dry powder, it absorbs the fixed air also in this state,—in a short time loses all its qualities as a quick-lime, and, chemically considered, differs in no respect from the stone of which it was composed.

If no more water has been added at slaking than was barely sufficient to make it *fall*, and, if it be kept dry ever afterwards, or mixed with any dry powder, it does not harden as it absorbs its air, but remains in a powdery state,
to

to all appearance in no respect differing from *quick-lime*.

But, if a larger proportion of water has been added than was necessary for slaking the lime,—in proportion as it absorbs its air and becomes *mild*, it concretes into a coherent mass; first upon the surface, which quickly becomes covered with a hard crust, greatly resembling the thin crust that is formed on the surface of moist earth by a moderate frost.—Masons, ignorant of the real cause of this phaenomenon, call it *frosted* lime; although their own experience ought to satisfy them, that this crust is formed as readily in summer as in winter.

As lime that has absorbed its air in any of these ways, is altogether unfit for becoming a cement, it is evident that a great change may be produced upon the quality of any lime, by having allowed less or more of it to be in this state, before it is worked up into mortar.

§ 13.

If a large quantity of water be added to fresh flaked quick-lime, and beat up with it into a thin paste, the water dissolves a small proportion of the lime, which, as it gradually absorbs its air, is converted into chrystals; between the particles of which chrystals, that part of the lime that was not dissolved, and the other extraneous

matters that may have been mixed with it, are entangled, so as to form a firm coherent mass of the whole.

The paste formed in this manner is called *mortar*; and this heterogenous, imperfectly semi-chrystallized mass, constitutes the common cement used for building ordinary walls.

These circumstances being premised, it will not be difficult to comprehend what are the particulars that are necessary to form the most perfect cement of this sort.

§ 14.

Since lime becomes a cement only in consequence of a certain degree of chrystallization taking place in the whole mass, it is sufficiently obvious, that the firmness and perfection of that cement must depend upon the perfection of the chrystals, and the hardness of the matters that are entangled among them. For, if the chrystals are ever so perfect and hard of themselves, if they be separated from one another by any brittle incoherent medium, it is evident that the whole mass must remain in some degree brittle and incoherent.

§ 15.

§ 15.

Water can only dissolve a very small proportion of lime, even when in its most perfect saline state*; and, as happens with all other saline matters, no more of the lime can be reduced to a chrystalline mass than has been actually dissolved in the water.—Hence it happens, that, if mortar be made of pure lime and water alone, a very small proportion of the lime only can be dissolved by that small quantity of water that is added to it. And, as this small proportion alone can be afterwards chrystallized, all the remaining undissolved particles of the lime will be entangled among the few chrystals that are formed.

And, as the undissolved lime in this mass will in time absorb its air, and be converted into *mild* calcareous earth, without having had a sufficiency of water to allow it to chrystallize, it must concrete into a friable mass exactly re-

* The reader will observe, that I often speak of lime in its *saline* state. I presume he will easily understand that, by that phrase, is meant lime, while it remains capable of being dissolved in water;—that is, as long as it remains deprived of its fixed air;—or, in other words, while in its *caustic* state.

sembling chalk: It follows, that this kind of mortar, when as dry as it can be made, and in its highest degree of perfection, will be always soft, and easily crumbled into powder.

§ 16.

But if, instead of forming the mortar of pure lime alone, a large proportion of sand be added to it, the water will, in this case, dissolve as much of the lime as in the former; and the particles of hard sand, like sticks or threads when making sugar candy, or other chrystals, while surrounded by the watery solution, will help to forward the chrySTALLIZATION, and render it more perfect than it otherwise would have been, so as firmly to cement the particles of sand to one another.

And, as the granules of sand are perfectly hard of themselves, so as not to admit of being broke down like the particles of chalk, it necessarily follows, that the cement made of these materials must be much more perfect, in every respect, than the former.

§ 17.

That the reader may see the full force of the
above

above reasoning, it is necessary he should be informed, that, when calcareous matter is reduced to a caustic calx, it becomes in every sense of the word a perfect saline substance, and is, in this state, as entirely soluble in water as common salt or sugar; although with this difference, that lime can be suspended by water only in a much smaller proportion.—Water can dissolve one third of its weight of common salt, and keep it suspended in a fluid state; but it can hardly dissolve one thousandth part of quick lime, before it is saturated*.

But,

* The term *saturation* is employed to denote that state of a fluid when it has dissolved as much of a solid body as it can possibly suspend in it at one time.

When any saline substance is put into water, it is dissolved by the water, and suspended in it till it attains what is called the point of saturation;—after which, if ever so much salt be added, not one particle more will be dissolved,—but it will remain at the bottom in its original solid state.

Water dissolves very different proportions of different salts before it is saturated. It will dissolve its own weight of Glauber's salt,—one third of its weight of common salt,—and not one thousandth of its weight of lime.

Hence it may very readily happen that, altho' any particular salt could be wholly dissolved in water, a part of the salt may remain untouched, if too much has been added—Thus, if one ounce of lime is put into ten ounces
of

But, although lime be as entirely soluble in water, *when in its caustic state*, as any other purely saline substance, it so quickly absorbs its air, as to have some part of it rendered *mild* before it can be wholly dissolved on any occasion, in which state water cannot act upon it;—so that, to obtain a total solution, that proportion of it that becomes mild, requires to be again and again calcined, after fresh solutions have been drawn from it.

As such a large proportion of water is necessary to dissolve any quantity of lime, it seldom happens, even in making lime-water, but that more lime is added than is sufficient to saturate the whole of the water.—In which case, some of it still remains at the bottom, in a condition capable of being dissolved, if more water be added to it.

But lime, it has been already said, differs from purely saline substances in this respect, that it cannot possibly be long suspended in water; for it soon absorbs its air even from that element, and is thus reduced to a mild state, when it

of water, that water will become saturated before it shall have dissolved one third of the quick-lime,—and the remainder will remain in a solid state untouched.

immediately

immediately chryſtallizes, and ſeparates from the water *.

In

* Although purely ſaline ſubſtances, *in every ſtate*, continue to be ſoluble in water, yet many of them become more or leſs ſo, in proportion to the quantity of air that is united with them at the time; and *in ſo far* reſemble lime in this particular, that they are more eaſily diſſolved when deprived of their air than when united with it.

Alkaline ** ſalts, ſtrictly ſo called, like lime, may be either in a *cauſtic* or *mild* ſtate; which appellations they in like manner obtain when they are deprived of their air, or united with it.

When theſe ſalts are in a *cauſtic* ſtate, they are ſoluble in water *in any proportion*. They have even ſuch a tendency to unite with it when in this ſtate, that it is extremely difficult, if not altogether impoſſible, to free them from the water till they are reduced to a mild ſtate.—No art has ever yet been diſcovered by which a cauſtic volatile alkali could be exhibited in a ſolid form; and, although dry concretions of the fixed alkali are ſometimes obtained while it is poſſeſſed of a certain degree of *cauſticity*, yet theſe are only effected in conſequence of ſome part of it becoming mild in the operation; nor can they be kept in that ſtate without the utmoſt care.

Ordinary pot-aſh is an alkaline ſalt obtained from the aſhes of burnt vegetables. This is, in ſome meaſure, deprived of its air in burning the plant; but, during the proceſs, before the watery ſolution is thoroughly evaporated to dryneſs, the alkali has abſorbed ſome part of its air, and is in ſome meaſure rendered mild, ſo as to admit of being reduced

** The term *alkali* is employed to denote a certain claſs of ſaline bodies, whoſe moſt certain diſtinguiſhing characteristic is, that they may be united with acids, and with them form *neutral* ſalts, as nitre, common ſalt, &c.

In consequence of this peculiarity, it necessarily happens, that, in proportion as these
chrystals

to a dry state by the force of fire. But, as the salt is not in this state *perfectly* mild, the caustic part of the alkali attracts the moisture from the air with so much power, as soon to obtain enough to reduce the whole to a watery solution, if it is not preserved from damp air with the utmost care.

This, and every other saline substance that attracts moisture from the air, and dissolves in it, is called a *deliquescent* salt.

But, if this alkali be exposed to the air for a sufficient length of time, till it has slowly absorbed its whole proportion of fixed air, and with it has become one chemical mixt, forming a *perfectly* mild alkali; it is then capable of being dissolved in water *only in one certain proportion*, like other salts; and may be made to shoot into regular chrystals, which may be kept in a solid dry state, when the atmosphere is in a due temperature of heat, in the same manner as any other salt.

In this case, the alkali, it is plain, leaves the water as soon as it has united with its air, in the same manner as lime separates from water, and assumes a dry chrystalline form. The alkali may indeed be again dissolved by adding a larger proportion of water, which the other cannot;—but, in the first particular, the parallel is alike.

Common salt is, in like manner, in part decomposed * by the violent heat that takes place in our ordinary way of boiling it.—A part of its acid is dissipated; the alkali that remains is left in its *caustic* state. Hence it has a perpetual tendency to absorb water;—in consequence of

* Common salt is a compound substance formed by the union of a particular acid with the *fossil* alkali.

which

chryftals feparate from lime-water, a part of it becomes pure water again, and is instantly capable of diffolving as much cauftic lime as it had loft by the former chryftallization; fo that it

which the whole becomes a deliquescent falt. If the evaporation is made flow enough, the chryftals are more perfect; and it may be eafily kept dry in the ordinary ftate of our atmofphere.—This is the reafon why great falt may be more eafily kept dry than fmall falt.

If, however, the alkali that is mixed with the falt had not been in a cauftic ftate, it is well known it would not have *deliquesced*; for the *natrum* of the antients, or the *fossil alkali* of the moderns in its native *mild* ftate, is a firm chryftalline falt, much refembling nitre, from whence it originally derives its name.

Exactly fimilar to thefe, are the changes produced upon common fugar, by the different proceffes it may be made to undergo. Sugar is a folid concrete, obtained by evaporating to drynefs the juice of the fugar cane. In the ordinary procefs for obtaining that fubftance, it is deprived of fome part of its fixed air,—and is haftily concreted into an imperfect fort of chryftalline mafs. In this ftate, it is poffeffed of a certain degree of acrid caufticity; and can be diffolved in water in any proportion, from the flighteft degree of impregnation to perfect drynefs.—But, when it is placed in proper circumftances, and is allowed time to abforb its air,—like the other fubftances above mentioned, it can only be diffolved in certain proportions, and therefore quits the water as it gradually unites with its air; and affumes a regular chryftalline form.

Thefe chryftals are diftinguifhed by the name of *sugar candy*, and are well known to be more difficultly foluble in water,—to be a milder and lefs acrid fweet,—and to poffefs many other qualities different from the fugar of which they were originally formed.

it immediately acts upon, and dissolves another portion of the quick-lime that remained below, after the water was saturated. This is also chrySTALLIZED in its turn, and a fresh solution takes place; and so on it continues, constantly chrySTALLIZING and dissolving a-new, as long as any caustic lime remains in the water to be dissolved.

It is in consequence of this constant action of the water and air that lime-water always continues of an equal degree of strength, so long as any caustic lime remains in the vessel for the water to act upon, notwithstanding the large proportions of calcareous chrySTALS that are continually separating from it.

§ 18.

From the foregoing induction it appears, that, when a large quantity of sand is mixed in the mortar, *it* will bear a great proportion to the whole mass; so that the water that may be mixed with the mortar will be much greater, in proportion to the quantity of lime contained in this mortar, than if the whole had consisted of pure calcareous matter.—And, as the sand absorbs none of that water, after a part of the lime is chrySTALLIZED and separated from the water, it is left at liberty to act once more upon

on those few particles of caustic lime that may still remain in the mortar, which will be dissolved and converted into chrystals in their turn.

In this manner, it may happen, in some circumstances, that a very large proportion of the lime may become chrystallized, so that the mortar shall consist almost entirely of sand enveloped in chrystalline matter, and become in due time as hard as stone itself;—whereas mortar, consisting of pure lime without sand, can hardly ever be much harder than chalk.

§ 19.

It is not, however, to be expected, that, in any case, this dried mortar will assume that transparent chrystalline form, or the compact firmness of marble or lime-stone.—In mortar, in spite of the utmost care that can ever be taken, a very considerable quantity of the lime must remain undissolved; which undissolved lime, although it may be so much separated by the sand and chrystallized lime-stone, as not much to affect the hardness of the mortar, yet it must still retain its white chalky-like appearance.

But as marble and lime-stone are always formed by those particles of lime that have been wholly dissolved in water, and from which they have

have been gradually separated by a more flow and more perfect mode of chrySTALLIZATION, they have nothing of that opaque *calx* like appearance, but assume other colours, and appear more firm, uniform, and compact; the sand and other matters that may be enveloped in them being entirely surrounded with a pure chrySTALLIZED matter.

§ 20.

To obtain the most perfect kind of mortar, however, it is not enough that a large proportion of sand should be employed, and that that sand should be intimately mixed with it.—It is also of the utmost importance that a large proportion of water be added. For, without this, it is impossible that a large proportion of the lime can be chrySTALLIZED, and the mortar, in that case, would consist only of a mixture of chalky matter and sand, which could hardly be made to unite at all—would be little more coherent than sand by itself, and less so than pure chalk.—In that case, pure lime alone would afford rather a firmer cement than lime with sand.

§ 21.

§ 21.

It is also of very great importance that the water be retained as long in the mortar as possible. For, if it be suddenly evaporated, it will not only be prevented from acting a second time upon the lime, after a part of what was first dissolved has been chrystallized, but even the few chrystals that would be formed when the water was suddenly evaporating, would be of themselves much more imperfect than they otherwise most certainly would have been.

Common salt consists of chrystals hastily formed by a sudden evaporation of sea-water by means of fire, has the appearance of a dry whitish calx, that may be easily broke in pieces: The same salt, when slowly chrystallized by a gentle evaporation in the shade, consists of large cubical chrystals, as transparent, and little softer, than crown glafs.

Ordinary lump-sugar, it has been said, likewise consists of another substance hastily con-creted by a sudden evaporation of the fluid in which it was dissolved:—Sugar-candy is the same substance, slowly chrystallized by a more moderate evaporation.—Every one knows what a difference there is between the firmness of these

these two substances.—As great must be the difference between the firmness of that cement which has been slowly dried, and that which has been hastily hardened by the powerful action of a warm air.

It is owing to this circumstance that the lime which remains all winter in a mortar-tub, filled with water, is always found to be much firmer, and more coherent than the mortar that was taken from the same tub, and used in any work of masonry; although, in this case, the materials were exactly the same.—From the same cause, any work cemented with lime, under water, if it has been allowed to remain unhurt till it once become hard, is always much firmer than that which is above the surface of the water.

§ 22.

To make the reader comprehend the full force of the foregoing reasoning, I would compare lime cement, or mortar, to a mass of matter consisting of a congeries of stones closely compacted together, and united by a strong cementing matter, that had, while in a fluid state, pervaded all the interstices between the stones, and had afterwards become a solid indissoluble substance.

If

If the cementing matter is exceedingly hard and coherent, and if the stones bedded among it are also very hard and firm, the whole mass will become like a solid rock, without fissures, that can hardly be broken to pieces by the power of man.

But, although the cement should be equally firm, if the stone of which it consists is of a soft and friable nature, suppose chalk, or sandstone, the whole mass will never be capable of attaining such a degree of firmness as in the former case; for, when any force is applied to break it in pieces, although the cement should keep its hold, the solid matter cemented by it would give way, and the whole would be easily broke in pieces.

Now—in mortar, the sand that is added to it represents the stones or solid matter in the composition, the particles of which are united together by the lime that had been formerly dissolved, and now chrystallized, which becomes an exceeding solid and indissoluble concretion.

And, as the particles of sand are of themselves exceedingly hard, and the cement by which they are united equally so, it is plain, that the whole concretion must become extremely firm, so as to require a very great force to disunite any particle of it from the whole mass.

But

But if, instead of employing sand, the only solid body that is entangled among the cementing matter should be chalk, (which, as has been said, must always be the case when the mortar consists of pure lime alone), or any other slightly coherent substance, let the cementing particles of that composition be ever so perfect, it is impossible that the whole can ever attain a great degree of firmness; as these chalky matters will be easily broke asunder.

§ 23.

Many conjectures have been made about the nature of the lime-cement employed by the antients. It has been thought they possessed an art of making mortar, that has been long since entirely lost; as the cement in the walls that have been built by them appears to be, in many cases, much firmer than that which has been made in modern times.—Yet, when the mortar of these old buildings is analyzed, it is found to consist of the same materials, and nearly in the same proportions which we now employ.

It is probable, however, that their only secret consisted in making the materials more perfectly than the rapidity or avarice of modern builders will permit, in employing their mortar in a
much

much more fluid state than we do now, and in allowing it to dry more slowly; which the immoderate thickness of many of their walls would naturally produce, without any pre-concerted design on their part.

Tradition has even handed down to our times the memory of the most essential of these particulars; as the lower class of people, in every corner of the country, at this moment, invariably believe, that these old walls were composed of a mortar so very thin, as to admit of its being poured, like a fluid, between the stones, after they were laid in the wall. And the appearance of these old walls, when taken down, seems to favour this popular tradition.

Nor have I any doubt but this may have been actually the case. The stones in the outer part of the wall were probably bedded in mortar, nearly as we practise at present; and the heart, after being packed well with irregular stones, might have the interstices between them entirely filled up with fluid mortar, which would insinuate itself into every cranny, and in time adhere as firmly as the stones themselves, or even more so, if the stones were of a sandy friable nature.

As these walls were usually of very great thickness, it might often happen that the water in this mortar, by acting successively upon different

ferent particles of caustic-lime, would at length be entirely absorbed by successive chrySTALLIZATIONS, so as to become perfectly dry, without any evaporation at all; in which case a very large proportion of the original lime must have been regularly chrySTALLIZED in a slow and tolerably perfect manner, so as to attain a firmness little inferior to lime-stone or marble itself.

Upon these principles, it is easy to account for the superior hardness of some old cement, when compared with that of modern times, in which a practice very different is usually followed, without having recourse to any other wonderful *arcana* whatever.

§ 24.

A modern French author, *Monsieur Lorient*, after meditating much upon this subject, imagines he has made a perfect discovery of the way in which the antients employed their quick-lime, so as to obtain such an extraordinary firm cement; from which discovery, he thinks, very important benefits may be derived to society.

According to his opinion, the antient cement consisted of lime and sand, nearly in the same proportions as are commonly employed for that purpose

purpose at present.—But, instead of making it of slaked-lime entirely, as we do now, he says, they employed a certain proportion of their lime *unslaked*, which they mixed with their mortar immediately before it was used.

This composition, he says, forms a firm and durable cement, possessing so many valuable properties, that I chuse to give them in the words of his own panegyrist.

“ In the course of the year 1770 *” says he †, “ Monsieur *Loriot* had the happiness to discover a kind of mystery in nature, which, for several ages past, had not, it is most probable, manifested itself to any body but himself;

* It deserves to be noted, that, about the same period, Mr. Doffie, secretary to the society of Agriculture and arts, in the Strand, London, published a receipt for making mortar in imitation of that of the antients, which was, in every respect, the same with this of Monsieur Loriot—which of these was the original discoverer, let the parties themselves determine.

† These extracts are taken from a treatise, entitled, *A practical Essay on Cement and artificial stone, justly supposed to be that of the Greeks and Romans, lately re-discovered by Monsieur Loriot, master of mechanics to his most Christian Majesty, &c. translated from the French original, lately published by the express order of the above Monarch.* London, Caddel, 1775. It appears to have been written not by Mr. Loriot himself, but some of his friends, as he is always mentioned in the third person.

a mystery on which all the merit of his discovery is founded.

“ Taking some lime, which had been a long time slaked, out of a pit covered with boards, and a considerable quantity of earth over them again, by which means the lime had preserved all its original freshness, he made two parts of it, and plashed and beat them both perfectly well.

“ He then put one of these parts, without any addition, into a glazed earthen pot, and in that condition set it to dry of itself in the shade. Here, in proportion as it lost its moisture by evaporation, it cracked and split in every direction; parted from the sides of the pot; and crumbled into a thousand pieces, all of them equally friable with the bits of lime dried up with the sun, which we usually meet on the banks of our lime-pits *.

“ With

* It is impossible, in reading this essay, not to remark the extreme ignorance or inaccuracy of the compiler of it on many occasions. The present paragraph affords a proof of it.—There can be no doubt but that lime, if it has been *very long slaked*, will lose all its qualities as a *quick-lime*, and become perfectly *effete*, let it be ever so carefully covered.—He gives no other test of the lime being still possessed of its caustic quality, but that it was covered.—For aught that appears, it might have been entirely *effete* lime; in which case, it is not at all surprising if it should not

“With regard to the other part, Monsieur Lorient just added to it one third of its quantity of powdered quick-lime, and then had the whole well kneaded, in order to make the two kinds of lime perfectly incorporate with each other. This done, he put this mixture likewise into a glazed earthen pot, as he had done the first; when, behold, it soon began to heat, and, in the space of a few minutes, acquired a degree of consistence equal to the best plaster, when prepared in the best manner. In short, it set and consolidated as readily as metals in fusion, when taken from the fire, and turned out a kind of instantaneous lapidification, having dried compleatly within a very small space of time, and that too without the least crack or flaw; nay, it adhered so strongly to the sides of the pot, as not to be parted from them without breaking it.

As to this passage, I shall only say, that I repeated the above experiment several times

not be capable of being converted into a cement of any kind.—Indeed, the effects he describes could only arise from its having been actually in this state.—For there is no man who does not know, that lime which has been some time flaked may, on many occasions, be employed as a cement, which, at least, is capable of adhering together, and not falling down at once into a loose powder as it dries.

with

with all the accuracy I was capable of ; with this only difference, that I employed lime that had lain a considerable time beat up with water, as is usual, to allow it to *four*, in the common language of masons, instead of lime that had been long covered up in a pit, like that which he employed.

The result was, what any man, who bestows a moderate degree of attention to the subject, and the experience of masons, might have expected ;—but extremely different from that of Monsieur Lorient.

The paste, made of the old flaked lime alone, dried slowly—became in time a mass slightly coherent, somewhat harder than chalk, it having been very pure lime I employed, without sand, or any other addition.

That which was made with the same flaked lime, with one third of its quantity of unflaked lime reduced to powder, kneaded through it, did indeed heat, as is usual in all cases when the lime is flaked,—swelled up, as is also usual ;—but acquired no degree of hardness greater than the other, nor differed in any respect from it, excepting that it absorbed the water more quickly ; and, in a day or so, after it was kneaded up, when it became pretty dry, some particles of lime-stone, that had not been burnt so perfectly as the rest, and were therefore longer of flaking, began to
heave

heave up afresh, having lain till this time unflaked.

On this account, although it must only be considered as an accidental misfortune that will not always happen, it was evidently a much worse cement than the other.

Such is the fact. Nor is it easy to see a reason why any beneficial consequences should result from the practice recommended.—It is well known, that, if water be added to burnt lime-stone *in any way*, the first effect is, that it heats, swells, and falls down to a powder.—Even under the water the effect is the same.—After that powder is formed, it may, by remaining under water, concrete into a solid mass; but, with whatever substances it is mixed, it must first separate before it unites. In the name of common sense, then, where can be the difference in first reducing it to that powdery state, and then beating it up with the water—or in pouring the water that is necessary to reduce it to powder upon it, and allowing that powder to remain as it may fall, without being beat up with the materials? Some of the watery particles will at first be absorbed—which is evidently a loss to the mortar—and the lime will be far less intimately mixed with the other ingredients, than if it had been properly blended and beat up with them after it was in its smallest powdery state; which

which must tend to render the mortar still less perfect.

Monsieur Lorient's panegyrist, however, is at no loss to produce reasons for these wonderful effects, that seem to him to be entirely satisfactory. He thus proceeds :

"The result of this addition of the quick-lime, surprising as at first sight it might seem, is notwithstanding so easily explained and accounted for, that it seems somewhat strange, that Monsieur Lorient should be the first to suspect and discover it. In fact, what can be plainer, than, that the sudden setting and consolidating of these two substances, must necessarily arise from the quick-lime's being carried, by a perfect amalgamation or admixture into the inmost recesses of the flaked lime, saturating itself with the moisture it there meets with, and thereby effecting the instantaneous and absolute desiccation *, which, because we are so well accustomed to it, we so little mind in the use of gypses or plaster."

If

* Any one who has bestowed a moderate degree of attention to the operation of flaking lime, as it is usually performed, must have observed many instances of that sort of sudden desiccation,—but without perceiving any of the other effects here mentioned.

In flaking lime-stone, especially when of the purest sort, so much water is necessary, and it is imbibed so slowly, that the operators, knowing it will be all drunk up in due

If I understand this paragraph, it means neither more nor less than that these two substances unite, because they necessarily do unite most perfectly.—If it has any other meaning, I am dull enough not to perceive it.

It would be tiresome to quote more passages from this treatise. Let it suffice to observe, that the author proceeds to tell, that this newly discovered cement dries and hardens almost under the hand of the operator, without cracks or flaws of any sort *;—that it neither expands nor contracts with the air †;—that it is impervious to moisture ‡,—and may not only be employed for making roofs to houses that are subjected to the continual dropping of water ||, basons,

due time, often throw so much on one place at once, as to reduce it to almost a fluid state.—This water soon sinks through it to the unflaked lime below.—But, if the lime on the top was regularly flaked before the last effusion of water, it retains a smooth uniform surface like plaster,—is dried almost entirely in a few minutes,—and, if not broke by the swelling of the lime below, continues ever afterwards to retain that form without crumbling away at all. If this is allowed to dry perfectly, and no more water is poured on it till it has absorbed all its air, it is perfectly chalk. It has the same hardness, consistency, &c. and cannot be distinguished from it, either in appearance or by any other property.

This, however, will never be the case, unless the lime has been perfectly pure, so as to dissolve in acids as entirely as sugar does in water.

* P. 31. † P. 32. ‡ Ibid. || P. 44.

aqueducts, canals §, &c. that will instantly contain water in any quantities,—but even finer works of the pottery kind ¶;—that it perfectly resists frost; with a long *et caetera* of other qualities which it would be tiresome to enumerate: For an account of which I must refer to the pamphlet itself.

That Monsieur Lorient has not discovered a cement possessing these peculiar qualities, it would be unbecoming in me to deny; seeing *it is affirmed*, that works have been erected with it that prove the facts in the clearest manner. But, that such effects will be invariably produced, merely by adding a certain proportion of unslaked lime in powder to mortar, as he asserts, or even by making the mortar entirely with powdered quicklime, I may, without hesitation, venture to deny, not only from the reasoning above given, but from actual experiment again and again repeated by myself; which is likewise, in some measure, corroborated by the experience of Mr. Dossie*.

For

§ P. 44. 45. 46. ¶ P. 52.

* Although Mr. Dossie recommends his new discovered cement for many qualities, yet he differs extremely from Mr. Lorient in his account of the manner in which the union is effected. For, instead of saying that ‘it consolidates as readily as metals in fusion when newly taken from the fire,’ he says it continues soft for some time, and only gradually hardens in the air. See Dossie’s Mem. of Agriculture, vol. 2. p. 20.

Mr. Dossie does indeed ascribe to his cement some of the

For these reasons, I am induced to think that, if Monsieur Lorient has really experienced these uncommon effects from the mortar he has tried, it must have been occasioned by some other unobserved peculiarity, and not merely by the circumstance to which he seems to ascribe it.—Possibly it may have been impregnated with *gypsum*, a saline substance, naturally abounding in France; and, as one of its principal ingredients is lime-stone *, there is nothing extraordinary in its being found in the same quarry chrySTALLIZED along with the lime-stone; nor any impossibility of its escaping undecomposed on some occasions during the calcination of the lime.—Or, it may perhaps have been otherwise accidentally mixed with the lime in these experiments.

the same qualities that Mr. Lorient attributes to his.—Some of these, however, are common to every sort of lime-mortar when carefully made; and, were it not a little foreign to our subject, it would be no difficult matter to show in what manner an inexperienced person might have his judgment misled with regard to some of the other qualities that may be called more equivocal.—The imagination is a more powerful magician than all the wise men of Egypt!

* *Gypsum* is an earthy salt, consisting of the vitriolic acid and calcareous earth.—It is best known among artificers by the name of *plaster of Paris*.

But,

But, in whatever way the *gypsum* may come there, if it be present, it is not to be doubted but effects, similar in kind, (though not in degree,) to what Mr. Lorient describes, would in some measure result from the practice he recommends. For, if *gypsum* be deprived of its moisture by calcination, it becomes a fine powder, greatly resembling the purest lime, which coagulates, if I may use that phrase, immediately upon the addition of water, and acquires at once all the firmness that it ever can be made to attain.

These properties of *gypsum* have been long well enough known; but it never acquires the stony hardness that lime-cement is sometimes endowed with; although it takes the smoothest polish of any cement we know; on which account it has long been employed as a plaster, where fine ornaments are required.

I have bestowed more attention on this performance of Mr. Lorient than my own opinion of its importance would have exacted from me; and it is purely in deference to the opinion of others that I have endeavoured to account for some of those *phaenomena* he describes,—supposing they have really happened. The inaccurate and unscientific manner in which that pamphlet is written, makes it afford the philosophic reader but very little satisfaction; and that affectation of the marvellous which runs

runs through the whole, and the many hyperbolic compliments paid to Mr. Lorient with which it abounds, are but ill calculated for giving the reader a favourable opinion of the intention of the compiler. Future experiments will bring to light those circumstances which seem to be at present doubtful and mysterious.—I now proceed to point out some other circumstances that may influence the quality of lime-mortar.

§ 25.

If lime-stone be sufficiently calcined, it is deprived of all its moisture, and of *all* its fixed air. But, experience shows, that lime-stone will fall to a powder on the effusion of water upon it when it is much less perfectly calcined, and while it still retains almost the whole of its fixed air. And, as we have hardly any other rule for judging whether lime-stone be sufficiently calcined, except this single circumstance of its falling to a powder when water is poured upon it, we may thus easily perceive, that the same lime may be more or less fitted for making good mortar, according to a circumstance that in a great measure eludes the observation of operative masons. For, if it should happen that all the lime-shells drawn from a kiln at one time

time were just sufficiently calcined to make it fall to a powder with water, and no more, that powder would be altogether unfit for making mortar of any kind.

This is a case that can seldom happen.— But, as there are a great many intermediate degrees between that state and perfect calcination, it must often happen that the stone will approach much nearer to one of these extremes at one time than at another, so that mortar may be much more perfect at one time than at another, owing to a variation as to this particular.

§ 26.

Every author who has written on the subject of lime as a cement, has endeavoured to ascertain what is the due proportion of sand for making the most perfect cement.—But a little attention to the subject will show, that all rules that could be prescribed as to this particular, must be so vague and uncertain, as to be of little use to the practical mason. For,

Besides the variation that may arise from a more or less perfect degree of calcination, and which has been just now taken notice of, it is a certain fact, that some kinds of lime-stone

stone are much more pure, and contain a much smaller proportion of sand than others do.

I have examined lime-stone that was so perfectly free of any mixture of sand whatever as to dissolve in acids as entirely as sugar does among water ;—I have also tried another kind that contained eleven twelfths of its whole weight of sand, and only one twelfth part of lime ;—and have met with other sorts in all the intermediate proportions between these two extremes.

Now,—it would surely be absurd to say, that the pure lime would require as small a proportion of sand when made into mortar, as that which originally contained a much larger proportion of sand than any writer on the subject has ever ventured to prescribe.

What adds to this uncertainty is the variation that may arise from the circumstance last mentioned, viz. the greater or less perfect degree of calcination that the stone may have undergone. For it ought to be remarked, that, although lime-stone, when pure, requires a very intense degree of heat to convert it into a *vitriified* * mass; yet, when sand is mixed with

* A *vitriified* substance is one that has been melted by heat, and assumes somewhat of a glass-like appearance.

the

the lime-stone in certain proportions, a very moderate heat is sufficient to convert the whole mass into vitrified *scoriae*, or, in the common language of the country, make it *run into danders*.

From this circumstance, it happens, that those who are possessed of a very impure lime-stone, are obliged to be extremely cautious not to give it an over-proportion of fuel, lest it should vitrify the stone; and they are very happy if they can get their stone calcined just enough to make it fall with water, and no more; so that, in general, it may be presumed that a very large proportion of *such* lime is *never* so sufficiently burnt as to be reduced to a perfectly caustic state, or to be capable of forming a cement.

But, as there is no danger, at any time, of giving *pure* lime-stone too much fire, those who possess *it* are not under the necessity of being afraid of erring on that side.—And, as it is a loss to them if the whole does not fall after it is drawn from the kiln, it is natural to think they will in general give it a full proportion of fuel. From hence it may be reasonably concluded that, in general, a much larger proportion of this kind of stone will be perfectly calcined than of the other sort.

At a venture, we may, with some shew of probability, conclude, that, about one tenth of
pure

pure lime-stone is not enough calcined to admit of being made into mortar; and that, of the most impure sorts of lime-stone, not above one fourth part of the lime contained in it is so much calcined as to be in a caustic state.

Let us see what variation this ought to produce as to the proportion of sand that might be added to the lime in the one or the other case. And, that the calculation may be more easily made, we shall suppose that the poorest lime-stone that is ever burnt contains one tenth of its whole weight of lime.

Ten parts of pure lime, before it could be reduced to the same degree of sandiness with the other, without considering the variation that arises from the burning, would require each of them nine parts of sand to be added. Therefore, ninety parts of sand should be added to the ten, to reduce them to an equality with the other lime in its native state.

But, if we are likewise to take into the account the variation above supposed, that arises from their different degrees of calcination, the account will stand thus :

Of the ten parts of pure lime, one is supposed to be not enough burnt to be capable of acting as a cement; so that there remains nine only in a perfect caustic state.

Of the ten parts of impure lime, nine are sand,

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and

and only one is lime ;—and, from this one is to be deduced three fourths as not enough calcined.—Hence there remains just one fourth of one tenth part (one fortieth) of pure caustic lime.

But this fortieth part of the whole is united to thirty-nine other equal parts of sand and uncalcined lime-stone.

There remained nine whole tenth parts of the pure lime in a caustic state ; to each of which must be added thirty-nine tenths, including the one tenth of uncalcined lime ;—so that, to reduce it to the same state with the former, there would need to be three hundred and fifty parts of sand added.

It seems to be altogether inconceivable that such a small proportion of calcareous matter could ever become sufficient to cement firmly together such a prodigious mass of other matters :—Nor do I pretend to say that this could actually be the case ; as there may be some error in the *data*. The following, however, I know to be a fact :

The best modern mortar I ever saw was made of lime that I myself had analyzed, and found it contained eleven parts of sand to one of lime. To this there was added between twice and thrice its whole bulk of sand *by measure* ; which may be allowed to have been at least three times its quantity *by weight*.

Now

Now, supposing that every particle of that lime had been so perfectly calcined as to be in a caustic state, there could not be less than forty-seven parts of sand to one of lime.—The reader may allow what he pleases for the uncaustic part of the lime, and make his calculation accordingly.—But, it is hardly possible to suppose that above one hundredth part of this mass, independent of the water, consisted of pure caustic calcareous earth.

But, whatever was the exact proportion of caustic lime, the mortar was made of these materials in the proportions expressed,—and was employed for pinning the outside joints of the stone walls of a house situated in a tempestuous climate, and exposed to every blast. It is now about fourteen years since it was finished, and I do not believe there has fallen to the ground, in all that time, one pound weight of the mortar.

Had this mortar been employed in building a thick wall, where it would have been suffered to dry slow enough, there seems to be little reason to doubt but it would have in time become as firm as the stones of the wall itself.

From these considerations, we may clearly see that it is impossible to prescribe any determinate proportion of sand to lime, as that must vary according to the nature of the lime

and other incidental circumstances, which it would be tiresome to enumerate, and which would form an infinity of exceptions to any general rule.

But it would seem we might safely infer, that the moderns in general rather err in giving too little sand, than in giving too much.

It deserves, however, to be remarked, that the sand, when naturally in the lime-stone, is more intimately blended with the lime than can possibly be ever effected by any mechanical operation;—so that it would be in vain to hope to make good mortar artificially from pure lime, with such a small proportion of caustic calcareous matter, as may sometimes be effected when the lime naturally contains a very large proportion of sand. But there seems to be no doubt that, if a much larger proportion of sand were employed, and if that were more carefully blended, and expeditiously worked, than is common, the mortar would be much more perfect than usual in modern times.

This I have tried experimentally, with the desired success.

§ 27.

Another circumstance that tends greatly to vary the quality of the cement, and to make a greater or smaller proportion of sand necessary, is the mode of preparing the lime before it is beat up into mortar.

When lime is to be employed for making plaster, it is of great importance that every particle of the lime-stone be flaked before it is worked up. For, as the smoothness of the surface is the circumstance most wished for in plaster, if any particles of lime should be beat up in it, and employed in work before they had had sufficient time to *fall*, the water still continuing to act upon them after it was worked up, would infallibly *flake* these particles, which would then expand themselves with great force, and produce those excrescences upon the surface of the plaster that are commonly known by the name of *blisters*.

Hence, therefore, if we hope to obtain a perfect kind of plaster, that shall remain smooth on the surface, and free of blisters, there is an absolute necessity to allow the lime to lie for a considerable time macerating in water before it is worked up.

This operation is called *souring*.

If

If the lime-stone be pure, and has been very perfectly calcined, there will be little danger but that the whole of the lime will fall at first:—But, if it has been less perfectly burnt, there will be many particles that will require to lie a long time before they will be reduced to a powder.—This operation is therefore more necessary with impure than pure lime.—But it ought on no occasion to be omitted, as there is not the smallest probability but *some* blisters would appear on plaster made even of the *purest* lime, if worked up and used immediately after it had been flaked.

It is also a common practice to *sour* the lime when it is intended to be used in *mortar*. And, although it is not so indispensably necessary in this case as when it is intended for plaster; yet, if properly performed, it is evident, that it must even here be of use; as any dry knots that may fall after the mortar is used, must tend to disunite the parts of it that had been already united, and render the cement much less perfect than if the whole had been properly mixed up with the materials before using.

But more circumspection is requisite in *souring* lime for mortar than for plaster. For,

As it is not necessary that plaster should be endowed with a stony degree of hardness, there is no loss sustained by allowing a great proportion

tion of the lime that is intended for that purpose to absorb its air before it be used; for a very small quantity of *quick-lime* will be sufficient to unite the whole into one slightly coherent mass.

Therefore the only circumstance necessary to be attended to in sousing lime for plaster is, that it be allowed to macerate long enough; as there is no danger of ever erring on the opposite extreme. It is indeed necessary that it should lie a very long time, on some occasions, before we can be certain whether all the particles are thoroughly flaked. I have known pieces of lime-shells lie upwards of six months exposed to all the vicissitudes of winter-weather, and *fall* after that time. Such slightly burnt stones are indeed usually separated in sifting the lime for plaster; but, as some small chips may escape, it is always safest to allow it to lie *in the four* a very long time.

This practice is also attended with another advantage of some consequence.—For if, by this means, a great proportion of the lime be allowed to absorb its air, and become *effete*, when it is beat up for use, the water can have no sensible effect upon that effete-lime—it will only separate the particles of caustic-lime more perfectly from one another, so as to suffer it to dry without cracks of any sort, and render the surface of the plaster much more smooth

smooth and entire than it could have been, if the whole had been employed while in its perfectly caustic state. By this means also those chrySTALLINE exudations, so common on newly plastered walls, will be most effectually obviated. On all which accounts, the practice of allowing lime intended for plaster to macerate *very long* with water ought never to be omitted, but in cases of necessity.

But, as lime is no sooner flaked than it begins to absorb its air,—and as it continues to absorb more and more every minute from that period, till it becomes entirely *effete*; so as to be rendered gradually less and less fit for forming a cement of any sort;—it follows, that if lime intended for *mortar* is allowed to lie long *in the four*, much of it will be converted into chalk, or unchrySTALLIZED *effete-lime*—in which condition it will neither admit of so much sand in using, nor ever become such a firm cement, as if a larger proportion of sand had been employed at first, and worked up as quickly as possible into mortar, and used.

This malady will be encreased, if the limestone has not been very well burnt; therefore care ought to be taken to chuse the very best burnt lime for *mortar*; in which case a very short time, if it has been carefully sifted after flaking, will be sufficient to make it *fall* as much

as is necessary. For the object of principal importance here is, to have the cement as *firm* as possible; and the bursting of a very small particle of unslaked lime amongst it afterwards, will not produce such a sensible inconvenience as it would have done in plaster.

Those, therefore, who wish to obtain the hardest and firmest *mortar*, will be careful to get *well burnt* lime, and allow it to macerate with the water only a *very short time* before it is used. But the best burnt lime I ever saw would require to macerate some days in the water before there can be a certainty that the whole will be sufficiently flaked *.

§ 28.

* It is no unsatisfactory proof of the justness of the foregoing reasoning to observe, that the practice which would necessarily follow from it is exactly what was followed by the antients, if we can rely on the account given of this matter by *Vitruvius* and *Pliny*.

Vitruvius, so far from recommending unslaked lime for making plaster, as Monsieur Lorient would suggest, recommends expressly that it should be *soured* or macerated in water—for the very same reasons as are given above; as it is only by that means, he says, that the plaster can be prevented from blistering.—His words are, (Lib. vii. cap. 2.) - - - “Tunc de albariis operibus est explicandum. Id autem erit recte, si glebae calcis optime, ante multo tempore quam opus fuerit, macerabuntur. Namque cum non penitus macerata, sed recens sumitur - - - habens latentes crudos calculos, pustulas emittit - - - Qui calculi dissolvunt, et dissipant tectorii politiones.”

Pliny

§ 28.

The reader, if he has followed me thus far, will easily perceive, that, although it be in vain to

Pliny points out still more clearly the difference between the quality of the lime necessary for making *mortar* and *plaster*—a certain proof that the antients had been very accurate in observing *facts*, as they could have no idea of the reasoning by which these facts might have been explained or corroborated.

“Ruinarum urbis,” says he, “ea maximè causa, quod furto, calcis *sine ferrumine suo caementa* componuntur. *Intrita* quoque quò *vetustior, èd melior*. In antiquarum (antiquis) aedium legibus invenitur, ne recentiore trima uteretur redemptor; ideo nulla (nullae) *teetoria eorum rima foedavere;*” Plin. Hist. Lib. xxxvi. cap. 23.

In this passage Pliny strongly contrasts *mortar* (*caementa*) with *plaster* (*intrita*). The first, he says, (by implication), ought always to be composed of lime *cum ferrumine suo*, that is, lime that still retains its *gluten*,—lime that still retains that quality by which it is enabled to unite detached matters into a solid body, and *glue* them, as it were, together. In other places of his work he describes it as *calcis quam vehementissimæ*, lime in its most acrid state, that is, perfectly *caustic* lime.

This quality, he plainly hints, it gradually loses by time, so as to come at length to be *sine ferrumine suo*; in which state, as it is impossible to become a firm cement for building, he severely reprehends those who use it as such.

But,

to expect those wonderful effects from the practice recommended by Monsieur Lorient, that he so pompously describes, yet it may happen, that, if circumstances accidentally concur to that end, a very perfect mortar may be obtained by following his directions. For, if the flaked lime that shall be employed has not had time to become in a great measure *effete*;—if the unflaked shells that are to be pounded have been *perfectly* calcined;—if the lime-stone has been of a sandy sort of itself;—if the sand added to it has been of a proper kind, and in due proportion;—and if these materials be carefully mixed before they are applied, there can be no doubt but the mortar would be very good :

But, although he condemns the practice of using that old and inert lime for mortar, he immediately adds, that, for plaster, it is better than new; because it is not so subject to crack in the work. “*Intrita quoque quo vetustior, eo melior - - ideo nulla testoria eorum rima foedare.*”

Monsieur Lorient quotes this passage, and contends, that *calcis sine ferrumine suo* means merely flaked lime, in opposition to his favoured powdered lime-shells.—What reason he has to think so, the reader is left to judge.—It is to be observed, however, that Monsieur Lorient does not confine the use of his cement to making mortar—Like those medicines that cure all diseases, it is equally proper for plaster; and indeed it is as a plaster he chiefly recommends it. There can be no doubt, however, from the authorities above quoted, that *antients* were as great strangers to the use of it in this sense as the *moderns*.

So

So that it may *sometimes* happen, that those who follow the practice recommended by him, in making mortar for ordinary uses, may be lucky enough to succeed to their wish. But, as these favourable circumstances may not chance to occur in other cases, they may be as far from their purpose as they possibly could be.

That gentleman, with his usual want of accuracy, takes no notice of any of these circumstances.—He only recommends that powdered quick-lime, by which he means pounded lime-shells, be mixed up with common mortar made of old flaked lime in certain proportions. He does not give the smallest hint as to the state of *old flaked-lime* to be used as common mortar; but seems to think it a matter of no moment, whether it shall have been so long flaked as to be perfectly *effete*, or the reverse;—he does not, indeed, seem to know any thing about that peculiarity of lime distinguished by that term.

But, independent of that circumstance, the practice he recommends is much worse in other respects than that usually followed in modern times, either for making plaster or cement,—especially the first. For, in the ordinary operation of flaking, those lime-shells that are not enough burnt, have some chance of being rejected when the lime is sifted; whereas, in this method of pounding the whole promiscu-
ously

ously, these will be mixed with the others; and therefore it may be expected that some of the particles will remain unslaked for a very long time, which will be in danger of disuniting and blistering the work long after it is put up.

§ 29.

Authors almost universally agree in asserting, that the hardest lime-stone affords a lime that will consolidate into the firmest cement; and hence it has been in general concluded, that lime made of chalk affords a much weaker cement than what is made of marble or lime-stone.

It appears, however, from the foregoing observations, that, if ever this be the case, it is only *incidentally*, and not *necessarily* so.

Lime made of pure chalk differs not in the least from lime made of pure marble.—Both consist of a fine impalpable powder, without any mixture of extraneous matter;—and, if they have been equally calcined, are possessed of the same chemical qualities, in every respect.—Indeed, nothing is more easy than to form artificial chalk from pure lime-stone, as I have more than once experienced, which the reader may also do, by following the directions
in.

in the margin*, if his curiosity prompts him to it.

* In flaking lime composed of *pure* lime-stone, it will be observed, that the pieces fall into powder much more slowly than when the lime-stone has contained any sand in it.

If a great quantity of water be successively poured upon a large heap of these pure lime-shells, without stirring them, and if it be allowed to lie some time afterwards, it will be found, on opening the heap, that some pieces of lime-shells have only expanded considerably in bulk by the operation of flaking, without being crumbled down to a powder.—These pieces, if allowed to remain in a close place, where they are not exposed to the vicissitudes of the weather, will still retain their form, and, as they gradually absorb their air, they acquire a sort of firmness of consistence, and in time become chalk, in every sense of the word;—having the same degree of firmness, of softness, and every other quality of chalk.

This is the most perfect resemblance of chalk that can be made; but, if any quantity of that pure lime be reduced to a very thin paste at the time of flaking, and be hastily dried to a certain degree,—it acquires a sort of consistency, so as to be capable of retaining its form. And, if this be kept in a place not exposed to the vicissitudes of the weather till it has attained its whole air, it will resemble chalk almost as much as the former, and might be employed for every purpose that the chalk is used for

The reader will please to observe, that this can only be done with lime that is *perfectly* free of sand; for, if it has the least particle of sand among it, no art can give it the softness of chalk.

And

And the practice of the southern provinces of Britain sufficiently confirms the justness of these observations. For, to the south of the Humber, on the east coast, almost all the lime they use is made of chalk; yet there are many buildings in these counties, in which the cement is as firm as in any part of the island:—Nor does the ordinary mode of building in these places indicate any deficiency in the quality of their mortar;—for their houses are almost all coated on the outside with a crust of lime, stuck full of small pebbles, which remain in it very firmly for many years.—We know well that this is the most trying manner of employing mortar.

There is, however, great danger that lime made of chalk should form, on some occasions, a weak cement, than that from lime-stone.

For, as chalk never contains any sand, its lime will always form a very soft cement, unless care be taken to mix a large proportion of sand with it in beating up the mortar; which is not so indispensably necessary in forming mortar from lime-stone;—as it sometimes contains so much sand as to form a pretty firm cement, without any additional sand at all.

Even if the lime-stone should be equally *pure* calcareous matter as the chalk, the lime of the
first

first has a chance of becoming a firmer cement than that of the last.

For, as it is impossible to reduce the pure lime-stone to a powdery *calx*, without subjecting it to the action of a very strong fire, which, by dissipating the water, and fully drying the chrystals, carries off the *whole* of its fixed air; so that the *calx* is almost entirely caustic.

But chalk may be reduced to *calx* by such a moderate heat as is scarce sufficient to dissipate any of its air; so that what assumes the appearance of lime made from it may be nothing else than a powdered *effete* calcareous earth, which never can become a cement of any sort.—But, as there is no danger of vitrifying chalk by overburning, this inconvenience may be entirely obviated, by a careful and perfect calcination.

In those countries, therefore, where chalk-lime is common, care ought to be taken to choose only that kind of it for mortar, that has been calcined by a *very strong* fire, and to reject that which has been burnt by furze or brakes, as unfit for that purpose.

But, it is obvious, that, as this defect arises entirely from the unskilfulness of the operator, which may be easily avoided, it ought not to be considered as any objection to the quality of the lime considered in itself.

§ 30.

It is unnecessary to extend our observations to all the other kinds of lime-stone that may be met with ; as these general observations on the two extremes, marble and chalk, may be easily applied to all the intermediate kinds. It has been already said, that the different friability of different sorts of lime-stone arises entirely from a smaller or greater degree of perfection in the chrySTALLIZATION, that must have been occasioned by accidental circumstances that have occurred at the time the concretion was effected, and can have no influence on the quality of the lime when it is once more reduced to the state of a *caustic calx*.

And, as it does not yet appear that there is the smallest difference between the chemical qualities of any one kind of fossile calcareous earth and another, *when perfectly pure*, there is no reason to suspect that there can be any difference between one kind of *lime* and another, *as a cement*, unless what may arise from the nature of the extraneous bodies that may be accidentally mixed with that calcareous matter in its native state,—or from its being more or less perfectly calcined.

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But

But the only extraneous matter that is ever found in lime-stone is *sand*, in greater or smaller proportions. And, as no lime-stone that *can be calcined*, contains such a large proportion of sand as is necessary for making a perfect cement, we may naturally conclude, that every kind of lime is equally fit for becoming a firm cement, if it be first reduced to a proper degree of causticity, and has afterwards a due proportion of sand *properly* mixed with it, before it be employed in work.

Different sorts of lime, no doubt, vary very much from one another in the proportion of sand they naturally contain, and therefore must require very different proportions of sand to be added to them before they can be made equally perfect as a cement. This is an oeconomical consideration of no small moment in some cases, as it may make one sort of lime vastly *cheaper* than another on some occasions, and therefore deserves to be attended to by every builder.—Directions shall be given in the Second Part of this Essay, by the help of which he may be enabled to discover the exact proportion of sand contained in any sort of lime he may wish to examine.

§ 31.

In the preceding parts of this Essay, I have spoken

spoken of *sand* as the only substance that is ever added to lime in forming cement ; but, as others have, on some occasions, been employed for this purpose, it will be proper here to point out their several excellencies and defects.

Almost the only substances that I have known used as an addition to mortar, besides sand of various denominations, are *powdered sand-stone*, *brick-dust*, and *sea-shells* that have been broke into small fragments.

And, for forming plaster, where closeness rather than hardness is required, the useful additions are, lime that has been slaked and kept long in a dry place, till it has become nearly *esfete*, powdered chalk, or whitening, and gypsum in various proportions; besides hair, and other substances of that sort.

Others that have been lately recommended by Monsieur Lorient, are balls of any sort of earth slightly burnt and pounded; the rubbish of old buildings, (by which I understand the old mortar after it has been separated from the stones,) reduced to powder, and sifted, or almost any other thing that can be reduced to a moderately fine powder.

From what has incidentally occurred relating to this head, the reader will be able to judge in some measure of the comparative value of these several additions: But to render the subject still

more clear, the following observations may be of use.

It is sufficiently certain that none of these additions enter into the composition, so as to affect its qualities as a *chemical mixt*;—they only operate in a manner purely *mechanical*. For, whatever the nature of the addition may be, it possesses the same qualities when so united, as if by itself, and may be separated by mechanical means from the compound unaltered. Therefore we need give ourselves no trouble about ascertaining their chemical qualities, but consider them merely as masses of matter that may be more or less fitted for this purpose by their peculiar form, degrees of hardness, &c.

It has been already shown, that *sand* ought to be preferred to chalky matters, chiefly on account of the hardness and firmness of the particles of which it consists.—And, as the purest sand consists of detached crystals, which are so hard as scarcely to admit of being broken into smaller parts, this kind of pure crystalline transparent sand is, perhaps, on this account, the most proper addition that can possibly be made to lime in forming *mortar*.

Sand-stone consists of an almost innumerable congeries of small particles of sand united to one another in a slight manner, by some kind of natural cement.—But, as it is troublesome to reduce

duce this kind of stone to its smallest component parts, and as the particles of it, when not reduced to that ultimate degree of fineness, may be easily broken into smaller parts, it can never be looked upon as such a proper addition for a lime-cement as the purest sand.

There are also many substances that are called *sand*, which are nothing else than fragments of decomposed granite, moor-stone, sand-stone, &c.—all of which may be easily reduced into smaller particles by moderate triture, and are liable to the same objections as pounded sand-stone.

But almost any of these is preferable to *brick-dust*. Fine clay, when *perfectly* burnt in the fire, may be made to assume almost a stony hardness. But common brick is so imperfectly burnt, as to admit of being reduced, without much trouble, to a fine impalpable powder; insomuch that it is often used, when in this state, for scouring polished iron or brass, especially if the brick has had no fine sharp sand in its composition.

As the rough particles of brick-dust may be so easily reduced to a fine powder, the mortar formed with it can, in no case, be of the most perfect sort.

But brick-dust is still liable to a greater objection,

jection, when considered as a component part of mortar.

Clay only loses its quality of absorbing water, and in some measure of dissolving in it, by a very perfect degree of burning, so that, if any part of it has escaped the violent action of the fire, that part, when mixed in mortar, will still be apt to absorb water whenever it may reach it, and lose its firmness, and make the mass, of which it is a part, crumble to dust.

It is exactly in this manner that all sorts of *marle* are liable to fall into powder when drenched in water, and exposed to the air; even although they sometimes appear, when dry, to be endowed with a stony hardness.

On this account, brick-dust, which usually consists of the imperfect burnt bricks, ought to be considered as a very dangerous mixture for mortar, and should never be employed but in cases of absolute necessity.

But the balls of other sorts of earth slightly burned, as recommended by Monsieur Lorient, must be, on many accounts, far less proper; as many of these sorts of earth cannot, by the action of fire, be deprived of their quality of absorbing water, and of becoming soft with it. So that he who should be foolish enough to employ these substances, may be certain that his cement will not only be incapable of attaining

ing any considerable degree of hardness at any time, but will also be liable to turn moist in a damp air, nor will be capable of retaining its firmness or cohesive quality in an exposed situation.

Powdered *lime-rubbish* is liable to the same objections with the softest sand-stone or brick-dust; as the particles of which it consists never can be endowed with the adhesive firmness that is necessary for forming a perfect cement.

Fine shells are perhaps firmer than any other substance, next to pure sand, and may be employed where the other cannot be got, if this abounds. I have seen a cement that was as little affected by the weather as any other, and had stood firm in the work a great many years, that had been originally formed with a sand consisting almost entirely of the fragments of shells.—But it had not the rocky hardness of some old mortar that we frequently meet with.

Powdered glass, if such a thing could be got at a moderate expense, would form a most perfect sort of mortar;—as it would not be liable to be affected with the weather,—would be sufficiently hard, and consist of very irregular fragments.

Thus, it appears, that, of all the substances that can be easily met with, *sand* forms the most proper

proper addition of lime in making mortar; on which account, it has been justly preferred to all others for that purpose.

Pure, firm, chrystallized sand, is better than any other sort:—But all pure sands are not equally proper for this use.

§ 32.

It has been already shown, that the principal advantages which resulted from the addition of sand in making lime-mortar were, that it augmented the quantity of hard indissoluble matter,—and put it in our power to employ a larger quantity of water in proportion to the lime, and thus forwarded the chrystallization of the calcareous matter, augmented the *quantity* of these chrystals, and rendered their quality more perfect. Those kinds of sand, therefore, which promote these purposes in the highest degree, will be best adapted for mixing with mortar.

But, if sand consists of irregular angular particles, a greater quantity of water will be retained in the vacuities formed between these angular pieces, than could have been, if the whole had consisted of round smooth globules; and therefore it is natural to think, that rough, angular sand, will be more proper for this use than that which is smoother.

Hence,

Hence, if equally pure, sea-sand, which consists of round globules, that have been worn perfectly smooth by the continued attrition upon one another on the shore, (like the larger pebbles in the same situation) will be worse than any other sort.—River-sand will be better than it;—and pit-sand, when quite free of earth, the best of all.

§ 33.

If the sand be hard, and the particles angular, it is perhaps of little importance whether these be very small or of a larger size.—The sand in the lime that formed the extraordinary firm cement, mentioned p. 242. was as small as could well be imagined.

Because sea-sand is usually smaller than any other sort, and is acknowledged to be less proper for making mortar than many other kinds of sand, a prejudice has been, in general, adopted against *fine* sand for this purpose.—But this, there is reason to imagine, is only a vulgar prejudice, arising from the peculiar figure of that sort of sand.

§ 34.

There is another and better reason for not employing sea-sand in mortar, viz. that there is always a chance that some particles of salt
may

may be formed among it by the evaporation of the sea-water upon the shore.—And, as common salt continues always to be a deliquescent substance, it will have a perpetual tendency to attract moisture from a humid air, and thus render the wall in which this mortar has been employed extremely damp and unwholesome.

It is from the same cause that any porous sort of stone, that has been taken from the sea-shore, continues at all times to be wet in damp weather. For, while the stone remained on the shore, its pores would be from time to time filled with salt-water, upon the evaporation of which, the salt it contained would remain behind within the pores of the stone, which would thus become endowed with the quality of attracting moisture from a damp air, sufficient to dissolve the salt, and make the watery solution ooze out through all its pores.

This is a phænomenon for which it is more easy to account, than to prescribe, an effectual cure.—Perhaps no art can render the stone sufficiently dry after it is once put into the wall. To let it lie for a considerable time in a stream of running fresh-water before it was employed, might obviate the disease.

§ 35.

For the same reason, lime that has been flaked with sea-water is always unfit for being used as a mortar. For, as it is impossible ever to extract that salt from the mortar, it continually attracts moisture from the air in damp weather, and oozes through the pores of the wall in form of drops of sweat, which again disappear when the weather becomes dry.

This is an inconvenience often felt:—But, as the real cause of it is seldom known, few persons are at proper pains to guard against it.—Those who obtain their lime by water-carriage are, in a peculiar manner, liable to be hurt by this circumstance; as the lime is, for the most part, flaked at the ship's side by the sea-water, which is more easily got than any other.

When lime that has been flaked in this manner is employed as a plaster, it is rather worse than when used as a mortar, as it has less sand added to it, and has fewer pores in the inside, in which the drops of water might be allowed to lodge; so that the wall becomes alternately covered with a crust of dry powdery salt, and with damp tears running down its surface.

Too much care, therefore, cannot be taken to avoid using lime that has been flaked with
sea-

sea-water—as it will be impossible, or extremely difficult, ever to render these walls perfectly dry.

I have thus enumerated, at much greater length than I originally intended, the several circumstances that contribute to render lime-cement more or less perfect. In doing this, I have had occasion to explain the nature of many of those calcareous matters which have been generally used as a manure, which will considerably shorten our labour in what remains of this essay.

If I have reprehended, with some degree of asperity, those who, either through ignorance, or a wilful intention to deceive, have endeavoured, by specious pretexts, to mislead the ignorant; I hope the candid will be rather ready to ascribe this to a desire of rectifying those abuses that might have been introduced by their means, than to any other motive.—I have never found fault but where it was necessary to correct *.

I now

* Before I quit this branch of our subject, I may be allowed to remark, that, although the discoveries of modern philosophers have enabled us to account for some of the *phenomena* relating to quick-lime as a cement, that were altogether inexplicable to the antients; yet here, as in almost every branch of natural knowledge,

we

I now go on to consider calcareous matters as a manure.

we are still far from having attained that summit of perfection which some may perhaps too hastily be disposed to imagine.—In many respects we have as yet been just able to penetrate the mysterious vale of nature so far as to let us know that much remains to be discovered, of which we have now only a very faint idea. The following hints will illustrate my meaning, and deserve the consideration of chemical philosophers.

There is little reason to doubt that *flint* is nothing else than calcareous matter combined with some substance that has hitherto eluded the knowledge of chemists.

It is likewise highly probable, that the native chrystalline concretion called *quartz* by naturalists, is only another modification of the same calcareous matter, combined with some other substance that prevents the action of acids upon it, and gives it other sensible qualities very different from calcareous substances in their ordinary state.

There is even some reason to suspect that all the other varieties of *chrystalline* earths, including sand of every denomination, are other modifications of the same calcareous matter.

Even *argillaceous* earths (clays), however different in appearance and natural qualities in their ordinary state, afford evident marks of the same original.

But, in what manner it comes to be so differently disguised in these several bodies;—what are their several component parts,—how they may be analyzed and re-compounded, are secrets of nature reserved for the discovery of future ages. And, till these are discovered, it is probable we will never be able to account for the manner in which the most perfect cement may be sometimes produced.

PART

AS A GEMINI

I now go on to consider certain matters

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P A R T S E C O N D.

Of Quick-lime, and other calcareous Substances, as a Manure.

IN the first part of this essay, I have been able to give, as I hope, a tolerably satisfactory account of the *rationale* of the operation of lime as a cement; and it is much to be wished that I could pursue the same method in the investigation of this substance as a *manure*. But, in this respect, I have as yet been able to discover no clue that could with safety be trusted for leading through the intricate labyrinth that lies before us;—on which account, I willingly shun the arduous undertaking.

It would be easy for me here to amuse the reader with a critical analysis of the several theories that have been invented by ingenious men to account for the *manner* in which lime operates as a manure.—It would be no difficult matter to demonstrate the defects of their several systems;—and I might, with great facility, make an idle display of *apparent* superiority, by
ridiculing

ridiculing their several hypotheses.—But, as I could not substitute any thing in their stead that would be more satisfactory to the sensible reader, I choose to wave this ungracious discussion; and shall content myself with enumerating a few *facts* concerning the use of calcareous substances as a manure, that it much imports the practical farmer fully to understand.

§ 1.

The first idea that occurs in reflecting on this subject is, that all substances in which calcareous matter is contained, have been successfully employed as a manure, at different times, and in different places.

Thus—*lime*,—*marle* of all sorts,—*chalk*,—*lime-stone-gravel*,—*shelly sand*, or pure *shells* of every denomination, have all been employed as manures with the greatest success.

§ 2.

And, as all these, excepting lime, always contain the calcareous matter in its *mild* state, we are led to conclude, that *they* operate on the soil merely as *calcareous*, and not as *saline*, substances.

Lime,

Lime, indeed, is sometimes applied to the soil in its *caustic* state, as it comes fresh from being flaked, but more commonly at some considerable distance of time after it has been burnt. However, as burning is the only mode usually employed for reducing lime-stone to powder, and thus preparing it for a manure, the opinion, in general, prevails, that calcination is as necessary for rendering lime capable of becoming a manure, as for making it fit to be employed as a cement.

It is, however, of importance for the practical farmer to be informed, that this is not the case.—Mr. Du-Hamel was the first who, from an accidental experiment, was led to believe, that *powdered lime-stone* was an equally efficacious manure as *lime* itself. He recorded the experiment as a great discovery.

Having had occasion to dress a marble chimney-piece for repairing one of his country-houses, the mason chose a lawn near the house as the most convenient place for hewing the stone.—After the operation was finished, all the large chips were picked up and carried away, that they might not disfigure the lawn;—but the fine powder that had been grinded off by the action of the chissel mixed so intimately with the grass, that it could not be gathered up.—In consequence of this very full dressing of

powdered lime-stone, the grass afterwards came up upon that spot with much greater luxuriance than on any other part of the lawn, and always continued to have a much livelier verdure.

From hence he, with good reason, concluded, that powdered lime-stone might be employed as a manure with success. To try if this would always be the case, he repeated the experiment several times, by causing some lime-stone to be pounded on purpose, and found that it never failed to promote the fertility of the spot on which he applied it in a very high degree.

§ 3.

I chose to relate this experiment at large, for the satisfaction of those who may be unacquainted with the *physical* cause of the difference between lime and lime-stone.—To such as are fully apprized of this, a little reasoning might have been sufficient to afford a certain conviction, that the result of the experiment must have been what Mr. Du-Hamel found it.

Lime is no sooner flaked than it immediately begins to absorb its air, and return to its former *mild* state,—or, in other words, it becomes *effete*;

effete; in which state it possesses the same chemical qualities in every respect as lime-stone.

If this be spread out thinly upon the surface of the earth, it absorbs its air in a very short time.—A few hours, in this situation, restores a large proportion of its air; and, in a day or two at most, it becomes perfectly *effete*; as masons experience when they sweep together the scattered particles that have lain round their heaps of lime, and attempt to use it in mortar by itself: For it is then no more coherent than sand, or moistened earth.

Hence, then, it must follow, that, in every case, *lime* is converted into the same state with *lime-stone*, in a few days after it is mixed with the soil; so that, if it produces any effect at all as *lime*,—as a *saline* substance,—it must only be at the *very first* when it is applied; and it must act ever afterwards merely as *powdered lime-stone*.

But it is well known, that lime produces scarcely any sensible effect as a manure at the beginning.—Even the first year after it is applied to the soil, its effects are inconsiderable, in comparison of what it produces in the second and succeeding years.—From whence we must conclude, that it operates upon the soil merely as a *mild* calcareous earth; and that its calcination is of no farther utility in preparing it for manure, than as a cheap and effi-

cacious method of reducing the lime-stone to fine powder.

§ 4.

It is of importance that these facts should be generally known;—because it may sometimes happen that good lime-stone shall be found in places where fuel could not be obtained for burning it; in which case, such lime-stone could be of no use to the farmer if calcination were absolutely necessary. But, seeing this is not the case, lime-stone, even in these situations, may be converted into a most beneficial manure, if a stream of water can be commanded sufficient for driving a mill for reducing the stone to powder.

I have seen the model of a mill that had been invented for that purpose, which was constructed on the same principles with an ordinary gun-powder mill.—It had several large massy stampers, composed of huge blocks of cast iron, that were successively lifted up and let fall by a wheel that caught their handles, and, after a proper time, slipped them again as it revolved round its axis.—These stampers fell with great force upon the lime-stone that had been previously broken into pieces of a moderate size, and placed in a strong trough formed for that purpose.

pose.—Through this trough, a small stream of water was conveyed, which washed away with it the small pieces of lime-stone, as they were successively reduced to powder by the stampers. This stream of water was received into a large reservoir, in which it was allowed to stagnate, and deposit, as a sediment, the lime-stone powder it brought along with it; the pure water flowing gently over a part of the brim, which was made lower for that purpose.

When the reservoir was nearly full of this fine powder, the work was stopped. The water was drawn off from the reservoir by taking out some plugs left for that purpose, at different heights, till all that was clear had run off.—The powdered stone was afterwards thrown out to the bank, and allowed to dry sufficiently for use.

I have heard that a mill, upon these principles, was erected by the Honourable the Trustees for managing the forfeited estates in Scotland, and that a good deal of limestone was pounded with it.—But as it was erected in the Highlands of Scotland, where roads were bad, and where there was but little spirit for improvements in agriculture;—as there was no public demand for the manure, after the experiment was sufficiently tried to show that it might be practised with advantage in other places, the mill was suffered to lie unemployed.

§ 5.

But, although this may be considered as a most valuable discovery for those who may have a good lime-quarry so situated as not to be within the reach of any kind of fuel for burning lime-stone;—yet, to such as can obtain fuel at a moderate expense, there can be no doubt but that burning is the easiest, and most efficacious mode of reducing lime-stone to powder that ever was invented; and therefore ought always to be adopted where necessity does not prevent it.

Reducing lime-stone to powder by calcination, is attended with this farther advantage to the farmer, that it considerably diminishes his expense of carriage.—*Pure* lime-stone loses about two thirds of its weight by being thoroughly burned; so that the man who is obliged to drive this manure from a great distance, will find a very considerable saving by driving it in the state of *shells*.—But, if it were reduced to a powder, by mechanical triture, he could not be benefited by this circumstance.

Many persons choose to drive lime-stone from a considerable distance, and burn it at home:—But, it is obvious they then sub-
ject

ject themselves to a very heavy charge in carriage, which would be avoided by an opposite conduct.—This, therefore, ought never to be practised, but where other circumstances may counterbalance this unfavourable one.

§ 6.

But, as lime-stone is often, in its native state, mixed with sand in various proportions;—and, as sand loses nothing of its weight by calcination, it must happen, that those kinds of lime-stone that contain the largest proportion of sand will lose least in calcination; and, of course, afford the weightiest lime-shells.

Hence, it is obvious, that those who are under the necessity of driving lime from a great distance, ought to be particularly careful to make choice of a kind of lime-stone as free from sand as possible, and to drive it in the state of *shells*; as they will thus obtain an equal quantity of manure at the least expense of carriage that is possible.

§ 7.

§ 7.

When lime is slaked, that which contains most sand *falls* most quickly, and absorbs the smallest proportion of water.—What is pure requires a very large proportion of water, and is much longer before it begins to fall.

Hence it happens, that those who drive sandy lime-shells in open carriages, must be very careful to guard against rain; because a heavy shower would make the whole fall, and generate such a heat, as to be in danger of setting the carts on fire.——Whereas *pure* lime-shells are in no danger of being damaged by that circumstance.——I have seen a cart loaded with such shells, which had been exposed to a continued shower of rain, as violent as is ever known in this country, for more than three hours, and seemed hardly to be affected by it in the smallest degree.

§ 8.

Lime-shells formed from the purest lime-stone, require more than their own weight of water

water to flake them properly *;—whereas some kinds of lime-shells that contain much sand, do not require above one fourth part of that quantity.

Hence, it is much worse oeconomy in those who have pure lime-shells, to flake and carry them home in the state of powdered lime, than it is in those who have only a sandy kind of lime-shells.

§ 9.

It is even, on some occasions, more advisable for those who have very sandy lime to drive it in the state of powdered lime, than in that of *shells*. For, as it is dangerous to give that kind of lime-stone too much heat, lest it should be vitrified, those who burn it can never be *certain* that the whole of the stone will fall to powder when water is added, till they have actually tried it.—Nor do they think it a great loss if some part of it should be imperfectly burned, as it requires much less

* I have found, by experiment, that pure lime-shells cannot be flaked with less than about one fourth more than their own weight of water. When flaked in the ordinary way, the same lime-shells took more than double their weight of water.

fuel on a future occasion than fresh lime-stone ; and therefore they much rather chuse to err on this than on the opposite extreme.

But, should any one attempt to drive this *poor* sort of lime in the state of *shells*, he would be in danger of carrying home many stones that would never *fall*, which would more than counterbalance the benefit he would derive from the want of the small quantity of water that is required to flake it.

On these accounts, it may be admitted as a general rule, that those who can have access to lime-stone that is free of sand, will save a *great deal* in the carriage of it by driving it in the state of *shells* ;—and that, on the contrary, it will be most oeconomical in those who can only get lime of a very sandy quality, to drive it in the state of powdered lime.

From hence it follows, that the practice which now prevails of carrying shell-lime by water from one part of the country to another, is only an imaginary saving, obtained at a very high risque, to those who drive shells of a sandy quality ; but a real and unequivocal advantage of very high importance to the community at large, if these *shells* are obtained from a pure lime-stone.

These observations relate only to the saving of carriage to the farmer—an article
of

capital importance to him.—It is proper now to take notice of some other particulars that may equally affect him in this way, as well as in the application of the lime to his ground.

§ 10.

A vague opinion, in general, prevails in every part of the country, that one sort of lime may be more valuable than another; but it does not appear that farmers have hitherto had almost any rule to direct them in the choice of different sorts of lime; some esteeming one sort *strongest*, as they term it, and some valuing another sort more highly, without being able to assign any satisfactory reason for the preference they give in either case.

It is of importance that this matter should be elucidated.

Altho' it does not always happen, yet, in many parts of the country, the real nature of lime is so little understood, that the weightiest lime is preferred to that which is lighter; because it is imagined the first has more *substance*, and will therefore produce a more powerful effect upon ground than the finest and lightest lime.

But there seems to be no reason to think that

that there is any difference in the specific gravity of different parcels of *pure* calcareous matter, when fully calcined; therefore, if there is any difference in the weight of various sorts of lime, it must arise entirely from a variation in the quantity, or *gravity* of some extraneous matter that is mixed with the lime.

And, as *sand* is almost the only extraneous body that is ever found in lime-stone;—and, as sand is always of much greater specific gravity than pure quick-lime,—it follows, that the weighty lime only owes its superior gravity to a larger proportion of sand that is mixed with it.

But *sand* is of no value as a manure; so that he who voluntarily purchases this kind of lime in preference to the other, is guilty of a great degree of folly; which will be the greater, if he has likewise to drive it from a considerable distance.—It would be better for him, if he is determined to use nothing but weighty lime, to buy such as is pure, if it can be obtained, and mix it with sand after he has got it home, so as to give it the gravity required. Some might laugh at this as a proof of his folly; and justly:—But it is surely less foolish in him to do this than to pay money for the sand, which he would thus obtain for nothing, and drive it from a distance, when he might have it at his door.

door. This practice would also be attended with the further advantage, of enabling him to know exactly what quantity of *real* lime he applied to his ground, as he would not be in danger of considering the sand as a part of it.

§ 11.

Those who have access to only one sort of lime-stone must be contented with it, whatever may be its quality. But, such as have an opportunity of chusing, may be benefited by the following observations:

Pure lime-stone, when fully calcined and flaked, is reduced to a fine impalpable powder, that feels soft between the fingers, without the smallest tendency to grittiness.—Such lime as contains sand, is never so fine nor so soft, but feels gritty between the fingers; and is more or less so, as the sand is coarser, or finer, or in greater or smaller proportions.

The lime from pure lime-stone is always of a bright white, when perfectly calcined, without a tendency to any colour.—When it has any colour, it proceeds from the sand in its composition.—There are, however, some sorts of sand that are of such a pure whiteness as not to de-
base

base the colour of the lime in the smallest degree ; but these are rare.

Hence it follows, that the best lime for the purpose of the farmer is that which is lightest, softest to the touch, and whitest.—The more they deviate from either of these tests of purity, the worse they are for him.

§ 12.

That the farmer may have under his eye at one time the several criteria of the purity of lime that have been enumerated in different places of this Essay, I chuse to mention them here all at one time.—If he is attentive to remark these peculiarities, he needs be very solicitous about examining the qualities of his lime by any more minute and troublesome trials.—They are as under :

If the lime-stone loses much of its weight in calcination, and the lime-shells are extremely light ;—if the shells require a very large proportion of water to slake them fully ;—if it is long before they begin to fall ;—if the lime-stone is not apt. to *run* (or be vitrified) in the operation of burning ;—if it falls entirely when it gets a sufficient quantity of water after it has been properly calcined ;—if it swells very much in slaking, and if the lime is light, fine to the touch,

touch, and of a pure white; he may be satisfied that it is extremely good, and may use it in preference to any other lime that is inferior to it in any of these respects.

These rules are perfectly sufficient to decide as to the comparative value of any two kinds of lime that may be opposed to one another, and may be relied upon with certainty.

§ 12.

But, such as may discover a new quarry of lime-stone, and who wish to ascertain with certainty its real value, before they put themselves to any expense about it, will do well to employ the following more accurate, and, in that case, more easy analysis.

As all calcareous matters are capable of being dissolved in acids—and as no other earthy matter can be dissolved in them—it follows, that, if a sufficient quantity of acid is poured upon any body that contains calcareous matter, this matter will be quickly dissolved, while the others are left behind; and the proportions of each may be accurately ascertained.

To try the exact value of every kind of lime-stone, or other calcareous matter—take a quantity of aquafortis *, or spirit of salt †; and

* Nitrous acid.

† Muriatic acid.

having

having prepared them, as in the margin †, put them into a glass or earthen vessel—add to that, by little and little, a known quantity of the matter you mean to examine, which had been previously dried, and reduced to powder.—

† All the mineral acids effervesce and unite with calcareous earths.—But, as the vitriolic acid (spirit, or oil of vitriol) does not *dissolve* the calcareous matter, but forms a new concrete, that still retains its solid state, it is not fit for this experiment.

And, as it sometimes happens, that a little vitriolic acid is mixed with either the nitrous or muriatic acids—it becomes necessary to be certain that this is not the case, before it is employed in this experiment.

The easiest way of trying if these acids are free from the vitriolic is, to put a little chalk into them before you employ them.—If the acid is pure, the chalk will dissolve very readily—but, if not, some part of the chalk will fall to the bottom, in the form of a pure white sediment.—When this is the case, add small bits of chalk, by little and little, till no more of that white sediment appears—after which the acid may be kept for use, as sufficiently pure.

If the nitrous acid is so strong as to have a slight brown or reddish appearance, it ought to be diluted with water till it assumes a greenish look—As it is bought in the shops for the use of dyers, &c. it is usually weak enough.

If the muriatic acid is so strong as to have a bright yellow colour—or emits fumes when the bottle is opened—it ought to be diluted, by adding water till it assumes almost a colourless transparency, with a very faint tinge of yellow.

When they are thus prepared, either of these acids may be used indiscriminately for this experiment, as they are equally proper.

After

After each addition, suffer the violent effervescence, or ebullition, that will ensue, to abate before more is added.—When the whole of the powder is put to the acid, and the effervescence entirely subsided, stir it about several times with a piece of tobacco-pipe, and allow it to remain for some time, that the acid may act upon every particle of the matter, and thoroughly dissolve it. And, to be certain that there has not been too little acid, put a few drops of fresh acid to the solution, which will excite a fresh effervescence, if the whole is not fully dissolved.—When no change is produced by this addition, it is a certain proof that the whole is already dissolved.

Take then a piece of filtering paper, thoroughly dry, the weight of which is also known—fold it properly, and put it in a glass funnel—pour the whole of the solution, with the matter that may have subsided, into the funnel, and allow it to filtre through the paper slowly.—When the fluid part has thus drained off, fill up the filtre again with pure water, to wash off the whole of the saline parts from the *residuum* *.—Add water in this manner till it comes off without any saline taste—suffer it then to drop off entirely—dry it thoroughly—and weigh the paper with its contents.—The difference between

* The matter that remains undissolved.

which, and what the powder and paper were at the beginning, is the whole weight of the calcareous matter; so that its proportion to the whole mass is perfectly ascertained.

In this manner, I have examined a great many different kinds of lime-stone, and have found them vary in all degrees of purity, from such as were entirely soluble in acids, as sugar or salt is in water, to others that contained only one twelfth of their weight of soluble matter, and eleven twelfths of sand.—The ordinary kinds of lime-stone contain from one third to two thirds of their weight of sand.—Hard chalk is usually a pure calcareous earth soluble in acids:—And some sorts of lime-stone may be met with that are equally pure;—but these are rare. The only extensive lime-quarries of such a pure lime-stone that I have met with are at Sunderland, in the county of Durham, where there are several quarries of exceeding fine lime-stone; the best of which belongs just now to Mr. James Galley of that place—There are some quarries farther up the river WEAR, the stone of which is of a much inferior quality.

Were all the stones in the same quarry equally pure, the above would be a perfect and unexceptionable method of ascertaining the purity of any lime-stone: But it often happens, that, in a quarry of the very worst quality, there are
some

some pieces found that consist of pure spar, that are entirely free of any mixture of sand; and, in other quarries of a better sort, there are often small veins of an impure sort of stone mixed through the rock; so that, if either of these should chance to be picked out as a specimen for trial, the result would not be just.

To avoid falling into this mistake, any one who wishes to make an accurate analysis of any new discovered lime-stone, will do well to take eight or ten stones from different parts of the quarry, that are somewhat different in appearance from one another; and, having taken a chip from each, pound the whole together, to afford a proper subject for the experiment.

The same experiment might be tried with *lime*—but it is evident, the proportions would be different in the same stone, from what they would be if tried before calcination—as lime wants its fixed air, &c. which it had when in the state of lime-stone. But, as the lime is more liable to be varied by accidental circumstances, it is best to try the experiment with lime-stone.

§ 14.

It is, in general, believed, that the lime made of the hardest lime-stone is *stronger*, as it is called, by which is meant more powerfully efficacious as a manure, than that which is made from materials of a softer nature.—Hence it is, in general, asserted, that lime made from chalk is much weaker, as a manure, than that which is made from harder lime-stone.

Nothing, however, can be more erroneous than this hypothesis.—In the former part of this Essay, I have had occasion to explain pretty fully what is the real difference between chalk and lime-stone—and nothing can be more certain, than that the lime made of chalk is purer than that made from almost any lime-stone—and contains a much larger proportion of calcareous matter;—on which account it must be more efficacious as a manure than any of these more impure kinds of lime.

The hardest lime-stone that I know is that belonging to Mr. Galley at Sunderland.—Its external appearance rather resembles flint than lime-stone; and I have known it shaped into flints for guns, and used as such with success—yet the lime made of this exceeding hard stone is as light, as white, and as soft to the touch,

as

as the purest chalk-lime.—It differs not from that in any respect—insomuch, that I defy the greatest connoisseur in these matters to distinguish between it and the purest chalk-lime, when perfectly calcined, by any other means than by the pieces of flint that are so often met with among chalk-lime.

And from this lime, obtained from these very hard stones, as perfect chalk may be artificially made, by the simple process described p. 254. as was ever obtained from any quarry in England.

From these considerations, therefore, I am obliged to conclude, contrary to the common opinion, that chalk-lime is, almost in all cases, more efficacious, as a manure, than any lime obtained from lime-stone, in equal quantities—as it is extremely rare to meet with a lime-stone that contains near such a large proportion of calcareous matter; on which account it ought always to be preferred by the farmer, where both can be had at the same price.

§ 15.

We know little certain about the mode in which lime operates, excepting that it acts merely in consequence of its being mixed with the soil in substance. If a heap of lime shall have lain

lain ever so long upon one spot, and be afterwards carried clean away from it, so that none of the particles of the lime remain to be mixed with the soil—that spot will not be richer, or carry more luxuriant crops, than the places around it—which, every one knows, is not the case with regard to dung.

Again—if lime be spread upon the surface of the soil, and allowed to remain there without being ploughed in, its effects will scarcely be perceived for several years, till it has had time gradually to sink through the sward and mix with the soil; after which its effects begin to be perceived—although much less sensibly, than if the same quantity of lime had been intimately mixed with the soil, by means of the plough and harrow.

I am no stranger to the improvements that have been made in Derbyshire, by means of lime without the plough; but this is no exception to what I have said.—The effects are slow, though certain. Those who inhabit countries that admit of the plough, are often advised to lay lime upon the grass, and are made to believe, that their pasture will be instantly mended by it, nearly in the same perceptible manner as if it had been dunged. This I myself have tried, and have seen it tried by others—but always found that the grass, for the first year, was rather hurt than benefited by it; nor
was

was it so much improved in succeeding years as if the same quantity of lime had been applied and intimately mixed with the soil.—In this mode of applying lime, therefore, it is long before it yields a proper return, and is not to be recommended to a poor man, unless where necessity obliges him to practise it.

§ 16.

If, then, lime acts upon the soil more efficaciously in consequence of being intimately mixed with it, we may naturally conclude, that it will produce a more sensible effect when it is reduced to exceeding small particles, than when it is applied to the soil in larger lumps, as these do not admit of being so intimately mixed with the particles of the soil.

But no method has ever yet been discovered for reducing calcareous matter to such small component parts, or of spreading it so evenly over, or of mixing it so intimately with the soil, as by calcination. Accordingly it is found, that *lime* will produce a very sensible effect upon the soil when applied in infinitely smaller quantities, than any other calcareous matter whatever.

Considered

Considered in this view, it can never be expected that lime-stone, reduced to powder by any kind of mechanical triture, will produce such a sensible effect upon the soil, as the same quantity of calcareous matter, in the state of *lime, if properly applied*; because it is impossible, by mechanical means, ever to reduce it to such a fine powder as it naturally falls into after calcination.

§ 17.

Much, however, depends upon the mode of applying the lime to the soil after calcination. If it is spread as soon as it is flaked, while yet in a powdery state, a very small quantity may be made to cover the whole surface of the ground, and to touch an exceeding great number of particles of earth. But, if it is suffered to lie for some time after flaking, and to get so much moisture as to make it run into clods, or cake into large lumps, it can never be again divided into such small parts; and therefore a much greater quantity is necessary to produce the same effect, than if it had been applied in its powdery state.

But if the soil is afterwards to be continued long in tillage—as these clods are annually broken smaller by the action of the plough and harrows,

harrows, the lime must continue to exert its influence a-new upon the soil for a great course of years—it will produce an effect nearly similar to that which would be experienced by annually strewing a small quantity of powdered lime over the surface of the soil. But, as the price of the lime must, in the first case, be paid by the farmer altogether at the beginning, which only comes to be successively demanded, in the other case—this deserves to be attended to, as it may become a consideration of some importance where lime is dear, and money not very plenty.

§ 18.

In few particulars are practical farmers more divided in opinion than about the quantity of lime that may be laid upon an acre of ground with profit, or even with safety. Some require that it should be applied in such small quantities as thirty or forty bushels to the acre; and aver, that, if more is used, the ground will be absolutely ruined—while others maintain, that ten times that quantity may be applied with safety.

A great variation may, no doubt, be produced in this respect, by a difference in the nature of the soil,—in the state of culture it is under
at

at the time,—in the quantity of calcareous matter with which it may have been formerly impregnated;—and, perhaps, a variation may sometimes arise from other circumstances, that have never yet been attended to.

A difference will likewise arise from the quality of the lime that is applied, and from the manner in which it is employed. Some kinds of lime contain, perhaps, ten times more calcareous matter than other kinds: And it has been showed above, that a very great difference may arise from the mode of applying the lime.

Considering all these circumstances, it would appear a little presumptuous in any one to prescribe positive rules that should be generally adopted in this respect.—This I shall not attempt—but shall relate, with candour, such observations as have occurred to myself in the course of a pretty extensive experience of this manure.

§ 19.

It is common to hear those who have had little experience of lime, as a manure, recommend very great caution, lest too great a quantity be employed, for fear of *burning the soil*, as they express

prefs it. This idea of *burning* has been evidently adopted from what is experienced by applying caustic lime to other bodies in large quantities, as it often corrodes and shrivels them up, and produces other effects which greatly resemble those of fire: But it cannot produce any such effects, unless there are vegetables growing upon it at the time. In that case, the vegetables might indeed be corroded by the lime, if rain should fall immediately after it was spread, when newly slaked.—But, as it loses this fiery corrosive power in a few days after it is spread, nothing of that kind can be expected to happen to the *soil*. Accordingly, we never hear of crops being burnt up with too great a quantity of lime, in those countries where it has long been used as a common manure—although it is there often employed in much larger quantities than in other places where it is more rare.

I myself have had the experience of lime in all proportions, from one hundred to above seven hundred bushels to the acre, upon a great variety of soils, and have always found that its effect in promoting the fertility of the soil has been in proportion to the quantity employed—other circumstances being alike.

The expense in most cases prevents farmers from employing this manure in greater quantities than those above mentioned; but accidental circumstances clearly show, that, if it were

were applied in much larger quantities, the effect would only be to promote the luxuriance of the crop in a higher degree.

§ 19.

A gentleman of my acquaintance, in whose veracity I perfectly confide, happening to be from home when a large field was limed,—and having no occasion for the whole quantity of lime that had been brought for that purpose, and laid down in one corner of the field, his servants, without driving it away, mixed what remained with the soil, altho' the lime lay there about four inches thick over the whole surface. The effect was, that, for many years afterwards, the grain was so immoderately luxuriant, that it fell over, and rotted before it came to the ear.—After many years, this luxuriance abated a little, so as to allow the grain to ripen;—but it was always much more luxuriant than any other part of the field.

An accidental experiment, nearly similar to this, fell under my own observation. It happened that the servants of another farmer laid, by mistake, a few heaps of lime upon a grass-field that he did not intend should be broken up at the time.—The mistake was soon discovered,

vered, and no more lime was laid down at that place; and the few heaps (about a bushel in each,) were allowed to lie neglected without being spread.—The field was pastured upon for seven or eight years after that, before it was converted into tillage; and the heaps were by that time become so flat, and so far sunk into the ground, that they could hardly be discovered.

Before it was ploughed up, the whole of the field was limed, and this part of it equally so with the rest; nor were the old heaps touched till the plough went thro' them in tilling the field, when the lime was there turned up, almost without any mixture of soil. The consequence was, that at every one of these heaps, a tuft of corn sprung up with such luxuriance as to be entirely rotted before harvest;—and, for many years afterwards, these tufts could be distinguished from the other parts of the field, at a very great distance, like so many buttons on a coat;—and perhaps continue so to this day.

From these experiments, as well as other considerations that will afterwards occur,—there seems to be reason to conclude, that, on soils that do not naturally abound with chalk, or other calcareous matter, there is less danger in giving too much lime than in applying too little;—except in those cases where an over luxuriance is dreaded.

§ 20.

I have often heard it urged as an objection to the use of lime as a manure, that, altho' it does indeed promote the fertility of a soil in a high degree at first, yet, in the end, it renders it much more steril than formerly; on which account, they say, it ought not to be at all employed.

This, like many other objections to useful practices, takes its rise entirely from the avarice and unskilfulness of those who complain.—It is chiefly heard of in those parts of the country, where it is not uncommon for a farmer, after once liming a poor soil, to take fifteen or sixteen crops of oats successively, without any other dressing or alternation of crops. It must be a good manure that enables these soils to produce such a number of successive scourging crops of any sort.—But it would be a marvellous one indeed, if it should prevent those fields from being exhausted by them.

But, is it not well known, that, in all the richest and best improved parts of the country, lime has been long employed as a manure?—yet, so far are these soils from being rendered steril by it, that it is doubtful if any art, without the assistance of lime, or some calcareous matter,

matter, could ever have brought these fields to their present degree of fertility. Those, therefore, who complain of the hurtful effects of lime as a manure, proclaim what they ought to conceal,—that they have had in their possession a treasure which might have enriched their posterity, but which they have idly squandered away in their own life-time.

§ 21.

We are not only unacquainted with the mode in which lime operates upon the soil, but we are even in a great measure ignorant of the actual changes that are produced upon the earth after this manure is applied. So much time is necessary to discover these,—and such accuracy of observation is required, that it will perhaps be long before the whole shall be fully ascertained. I shall mention a few that have occurred to myself.

It is often asked, how long the effects of lime may be perceived on the soil? and, if by this question it be meant to ascertain the length of time that the effects of lime will be perceptible in promoting the luxuriance of the crop after one manuring, it is no wonder that very different answers should be given, as the effects must vary with the quantity or quality of the
lime

lime employed,—the nature of the crops that follow—and many other circumstances that it would be impossible here to enumerate.

But, if it be viewed in another light;—if lime be supposed to alter the soil so as to render it susceptible of being affected by other manures in a more sensible degree,—so as to make it capable of producing crops that no art could otherwise have effected,—and to admit of being improved by modes of culture that would not otherwise have produced any sensible benefit;—the answer to the question would be more easy,—as, in this light, it is pretty plain that its effects will be felt perhaps as long as the soil exists.

I believe farmers are seldom accustomed to consider lime, or other calcareous manures, in this last point of view; although, when it comes to be enquired into, I doubt not but this will be found to be by far the most valuable effect of these manures. A few facts will best illustrate my meaning:

In Derbyshire, the farmers have found that, by spreading the lime in considerable quantities upon the surface of their heathy moors, after a few years the heath disappears, and the whole surface becomes covered with a fine pile of grass, consisting of white clover, and the other valuable sorts of pasture-grasses. This shows that
lime

lime renders the soil unfriendly to the growth of heath.

It is found, by experience, that, in all porous soils which are not exposed to too much dampness, in every part of Scotland where lime has not been employed, heath has a natural and almost irresistible propensity to establish itself. In those parts of the country, where lime has been much used as a manure, we find that the fields may be allowed to remain long in grass, without becoming covered with that noxious plant.

Again : It is well known, by those who have been attentive, and have had opportunities of observing the fact, that pease of any sort can never be successfully cultivated in any part of the country where lime or other calcareous manures have never been employed. If the ground be made as rich as possible with common dung, although the pease in that case will vegetate and grow for some time with vigour; yet, before they begin to ripen, they become blighted,—usually die away entirely before a pod is formed, and but rarely produce a few half-formed pease.

But, if the ground has ever been limed, altho', perhaps, at the distance of thousands of years from that period, it never loses its power of producing good crops of pease, if it is put in a proper tilth for carrying them at that time.

Again: In countries that have never been limed, the kinds of grafs that spontaneously appear, if left to themselves, are the small bent grafs, and feather-grafs.—In places where lime has ever been used, the ground, if exhausted, produces fewer plants of these grasses;—but, in their stead, white clover, the poa and fescue grasses chiefly abound.

The soil, in either of these cases, may become equally *poor*;—that is, may produce equally scanty crops: But the means of recovering them will be somewhat different. In the first case, a fallow is most always of use. In the last, it is often of no effect, sometimes even hurtful.—In the first, a moderate dressing of dung produces a much more sensible and lasting effect than in the other.—In the first, the quality of the grafs, as well as its quantity, rather improves by age.—In the last, these circumstances are reversed.

I might mention several other observations tending to show that ground which has been once impregnated with calcareous matter, acquires qualities from that moment which it did not possess before, which it ever afterwards retains, and never returns exactly to its former state.—But I have said enough to suggest this idea;—future observations will show how justly it is founded.

§ 22.

Altho' lime has such powerful effects on the soil, it does not seem ever to incorporate with the mold so as to form one homogeneous mass; but the lime remains always in detached particles, which are larger or smaller in proportion as it has been more or less perfectly divided when it was spread, or broken down by the subsequent mechanical operations the soil may have been made to undergo.

Hence it happens, that, in ploughing, if there chance to be any lumps of calcareous matter in a dry state upon the surface, they naturally tumble into the bottom of the open furrow, as soon as the earth is edged up upon the mold-board, so as to fall into the lowest place that has been made by the plough before the furrow is fairly turned over.

In consequence of this circumstance, it must happen, that, in the course of many repeated ploughings, more of the lime will be accumulated at the bottom of the soil than in any other part of it. And, as the plough sometimes goes a little deeper than ordinary, the lime that on these occasions chances to be deposited in the bottom of these furrows, will be *below* the ordinary staple of the soil, it will be useless for

the purposes of the farmer. It is commonly thought that the lime has *sunk* thro' the soil by its own gravity;—although it is certain that lime is specifically lighter than any soil, and can only be accumulated there by the means above described.

To obviate this inconvenience, it behoves the farmer,—in the first place, to be extremely attentive to have his lime divided into as small particles as possible at the time of spreading: For, if these are sufficiently small, they incorporate so intimately with the mold as to be incapable of being easily detached from it.—On this account, as well as others, it is always most adviseable to spread the lime when in its dry powdery state, immediately after slaking, before it has had time to run into lumps.

It is also of importance to plough the soil with a more shallow furrow than usual, when lime is put upon it;—especially the first time it is ploughed after the lime has been spread upon its surface. Because, at that ploughing, the lime being all on the surface, a larger proportion of it is turned into the bottom of the last made furrow, than at any succeeding ploughing; and therefore more of it will be buried beneath the staple than at any other time, if the furrow shall have been very deep.

This

This circumstance becomes more essentially necessary in ploughing grass-ground that has been newly limed; because, in this case, the lime is less capable of being mixed with any part of the soil than in any other.

It also becomes extremely necessary, in all succeeding times, to guard as much as possible against ploughing to unequal depths.

I have hitherto spoke only of *lime* as a manure;—but most of these observations, it will appear, may be equally applied to other calcareous matters. That the comparative value of these, and the real difference between them, when compared separately with lime, as well as with one another, may be fully understood, it will be necessary to consider each class of these substances separately, and point out with precision its peculiar distinctive qualities.

§ 23.

O F C H A L K.

All the writers on agriculture whom I have ever yet met with have considered the several classes of calcareous substances as distinct kinds of manures, and as possessing qualities extremely different from one another on many occasions. And hence it happens, that sometimes one of these,

these, which chances to have become the favourite of the author, and sometimes another, is highly recommended, while the others are despised as useless, or reprobated as pernicious.

In this manner, a very late writer*, with whom chalk is a peculiar favourite, says, 'I will lay it down as a certain and uncontroversial maxim, that *chalk* fresh from the pit, laid on and managed as before directed, in the proper season, will enrich every sort of earth it is laid upon; and that *lime*, on the contrary, laid on, at whatever time, or managed in whatever manner, will, after the first and second year, impoverish every soil it mixes with.'

It would be no difficult matter to produce other authors who, in a like decisive manner, reprobate the use of *chalk*, while they enlarge, without bounds, on the qualities of *lime*—and others who prefer *marle* of different sorts, or some of the other classes of calcareous earths, as the most valuable of all manures—while they condemn the others beyond all bounds of moderation.

The truth, however, is, that, although these authors may be right in recommending their own favourite manures, the beneficial effects of which they may have often experienced; as they usually condemn the others, merely from early

* The author of the complete English farmer.

early prejudices, or imperfect trials of them which have not succeeded, their decisions ought only to be considered as a proof of their being unacquainted with the real qualities of the matters they condemn, and of that presumptuous weakness which is ever the attendant of ignorance.

Nothing can afford a stronger proof that the author above mentioned was totally unacquainted, either in theory or practice, with the *real* difference between chalk and lime, than the positive distinction he has made between these two substances as a manure *.

§ 25.

It has been demonstrated, in the preceding part of this Essay, that lime differs not in any of its qualities from chalk, except that it is deprived of its fixed air—which can have no effect on it as a manure; because it again absorbs that fixed air before it has been a few days applied to the soil. After this period, therefore, what was originally *lime* is now *chalk*, and must have the same effects upon the soil, *in every respect*,

* The reader ought to be informed, that the *lime* he condemns is lime made from the very *chalk* he so much approves of.

respect, as an equal quantity of chalk, *equally spread upon it*, would have had.

It is easy, however, for those who attend to the *practice* of this gentleman, to account for his partiality for *chalk*. The quantity of chalk he recommends is twenty-five loads per acre; which, I suppose, may be about twelve hundred bushels*. He advises only ten or fifteen bushels of lime. Is it surprizing that the effects of these two dressings should be extremely different?

He ventured once to give a field of clay a dressing of sixty bushels of lime—after which he took,

1.	wheat,	produce	16 bushels,
2.	oats,	-	4 quarters,
3.	barley,	-	5 bushels,
4.	clover,	-	worth nothing.

Hence, says he, the lime has ruined my soil.

The soil was acknowledged to be poor—Instead of sixty, it is doubtful if six hundred bushels would have been sufficient to make it produce good crops under a management so execrable in other respects.

* A *load* I understand to be a waggon-load—which, I suppose, may contain between five or six quarters.

But

But—to leave off these ungracious strictures, I now proceed,

§ 26.

Chalk, as has been often said in the course of this essay, is a pure calcareous earth hastily concreted. Sometimes it is mixed with a small proportion of *argillaceous* * matter, in which state it approaches to the nature of *marle*. In either the one or the other of these states, it is employed as a manure in the countries where it abounds,

Chalk differs not from lime in any particular that can affect the farmer, unless it be that *lime*, by being in the state of a fine powder, admits of being more equally spread upon the ground, and more intimately mixed with the soil, than *chalk*; from whence it follows, that a much smaller quantity of lime may be employed successfully as a dressing for ground, than could possibly be the case with chalk.

In order, therefore, to make chalk produce the greatest possible effect upon the soil, it becomes necessary to reduce it into as small pieces as can be done—so that it ought to be an object of great importance to those farmers who have an opportunity of employing this substance,

* Clayey.

to discover what is the easiest and least expensive method of reducing it, as soon as possible after it is spread upon the soil, into very small portions.

Chalk is such a porous substance, that, when in its native bed, after long and continued rains, it is found to have imbibed a great deal of moisture by which it assumes a softish feel to the touch.

But if chalk be dug out of the pit, and dried slowly and perfectly by the heat of a summer's sun, its pores become, in some degree, contracted ;—it resists, in a great measure, the fresh admission of water, and acquires a much greater degree of hardness, than when it was originally dug from the quarry.

On the contrary, if it be taken from the pit during the wet weather in winter, and exposed to the rains that usually fall at that season, it has never time to dry—its pores remain quite full of water ; and, when the frost comes on, that water, in the act of freezing, being greatly expanded, bursts it forcibly asunder, and makes it crumble down into a slimy kind of powder. And, as the pieces that may remain undecomposed continue to absorb more as the rains fall from the heavens, the frosts that may succeed occasion a new dissolution—so that, by these alternate rains and frosts, the whole is in time

time totally divided, so as to admit of being pretty evenly spread and mixed with the soil.

For these reasons, it is always expedient to dig the chalk in the beginning of winter, and to spread it immediately upon the field as well as can be done, so as to expose it to the vicissitudes of the winter weather before it has had time to harden after being taken from the pit.

§ 27.

As the chalk ought always to be carried to the field while yet wet, it in a great measure prevents those who may be at a distance from the place where it is found, from being benefited by this manure; because the carriage of it would, in these circumstances, be extremely burdensome.

To obviate this inconvenience, it becomes a very economical practice to reduce it to the state of lime before it is carried home. For, in this way, the weight is not only much diminished by the dissipation of all the moisture from the chalk, but it can also be carried home in summer, when the weather and roads are at the best; and a much smaller quantity will produce

duce an equal effect, than when it is in the state of chalk.

Those, therefore, who have no other calcareous manure within reach of them but chalk, —when that is at a considerable distance, ought always to drive it in the state of lime.—But those who are close by the pit will, in general, find it more oeconomical to employ it in the state of chalk.

§ 28.

Chalk so much abounds in the southern parts of Britain, that ships sometimes bring it as ballast to the north ;—on which occasions it may be purchased at a moderate price by the farmer. —But, although it contains, perhaps, nearly an equal quantity of calcareous matter as the same bulk of some very pure kinds of lime, yet it will not be good oeconomy in him to purchase it at the same price with the lime,—as at least three or four times more chalk than lime will need to be applied to his soil before it produces an equal effect. For, as it is impossible to get that hard dry chalk reduced to small enough parts, a great quantity must be applied before it can produce any sensible effect ; and, although the effects of this manure may be lasting, yet
it

it is never any thing nearly equal to lime, if applied in equal quantities.

Another calcareous matter of great utility as a manure is *marle*; the distinctive properties of which fall now to be considered.

§ 29.

OF MARLE.

Few substances appear under a greater diversity of forms than marle. Hence it is usual for writers on agriculture to enumerate as distinct manures the several varieties of this general class of bodies. But, as all the different kinds of marle that have hitherto been discovered may be reduced to two general classes, viz. *earthy* marles, which are always found in fossil strata under the earth, and *shell* marle, which always retains evident marks of its animal origin, I shall consider each of these separately, as distinct substances.

§ 30.

Of Earthy or Fossil Marle.

The varieties of this class of bodies are distinguished by names, suggested by the appearance

ance they assume when fresh dug from their native beds. When they are soft and of an uniform texture, they are called clay marles;—when firm and hard, stone marles;—when these assume a thin foliaceous appearance, they are denominated slate marles, and so on.

But, whatever appearance they assume when fresh dug, or by whatever name they are known, they all agree in this, that, if they be exposed for a sufficient time to the action of the air, they crumble into smaller parts, and fertilize the earth to which they have been properly applied.

The ingenious Dr. Ainslie has demonstrated, by an accurate set of experiments, recorded in the Physical and literary essays, volume third, That all the varieties of this class of bodies contain a considerable proportion of clay, united with calcareous matter; whereas limestone, if it does not consist of pure calcareous matter, is usually united with sand in various proportions.

The calcareous matter in marle does not differ in any respect from that in limestone, and its proportions in many cases is the same in marle as in lime-stone,—so that the difference between the appearance and qualities of these two substances arises intirely from the nature of the heterogeneous bodies mixed with the calcareous matter.

When

When *marle* is exposed to the air, the clay in its composition absorbs the moisture that falls from the clouds,—swells with it,—becomes soft, and, gradually losing its cohesion, crumbles to pieces.—If lime-stone is exposed to the air, the sand in its composition is not in the least affected by moisture,—and it retains its original figure and dimensions for a great length of time.

When sand is mixed with the clay that enters into the composition of *marle*, it assumes a stony like appearance—and is more or less firm according to the quantity of sand, or other circumstances.—But, where there is clay at all in the composition, it will be gradually softened by water acting upon it; and, it is owing to this circumstance alone, that stone-marles fall in time to pieces when exposed to the air.

But, if *marle* be exposed to the action of a moderate fire, the clay in its composition becomes hard,—it is no longer capable of absorbing water, or of being affected by it in any degree; so that the *marle*, if not of a very pure sort, or such as contains only a very small proportion of clay mixed with the sand in its composition, will become firmer after burning than it was before, and be in this state with more difficulty reduced to powder, which is the reverse of what happens with lime-stone.

Marle,

Marle, therefore, is fit to act as a manure without any other preparation than digging it from the pit and spreading it upon the ground, —whereas lime-stone always requires to be reduced to a powder, either by burning or otherwise before it can be of any use in that way.

But, as lime-stone is at once reduced into much smaller parts by calcination than marle can ever be brought to at first, a much smaller proportion of lime may be equally spread over an acre of ground, than of marle; and therefore it will produce, in equal quantities, a much more sensible effect.

§ 31.

The discerning reader, who attends to these circumstances, will easily perceive the reasons for all the peculiarities of practice that prevail with regard to the application of lime and marle, and be able, without embarrassment, to judge in what cases it may be most for his profit to employ the one or the other of these manures, when they are both within his power.

He may ascertain the proportion of calcareous matter contained in the marle, by the same process already described for trying lime-stone, p. 287, and thus compare the intrinsic value of the lime and marle in any case. For this is
always

always in proportion to the calcareous matter contained in either.

He will easily perceive, however, that the same quantity of calcareous matter in the state of *lime*, will produce a much greater effect, than when it is in the state of *marle*; because it is divided into infinitely smaller particles,—can be more equally spread upon the ground, and more intimately mixed with the soil.

Hence it universally happens, that a much larger quantity of marle is applied at one dressing, than of lime. From one to two hundred cart loads of marle, is a common dressing to an acre;—that is, from three thousand to six thousand bushels;—whereas, from thirty to three hundred bushels of lime, is a common dressing for an acre of ground.

In these proportions, it is reasonable to think, that the effects of the marle will continue to be longer felt, than those of the lime: For, as the marle is gradually broken into smaller pieces every year, these will successively mix with the soil, and produce an effect nearly similar to what might be expected from an annual dressing of lime.

It may likewise be expected, that a full dressing of marle, in the proportions above named, will produce a more capital improvement upon light spongy grounds, than an ordinary dressing of lime;—because, independent of the calcare-

ous matter, the large proportion of clay applied in this manner may produce some alteration on the quality of the soil. This alteration, however, will be different according to the nature of the extraneous matter contained in the marle.

But, as all marles contain clay,—it is natural to think, that clay lands will not be benefited at all by this circumstance,—as the calcareous matter alone in the marle will be to these an useful addition.—Hence, light land will be in general more highly benefited by this manure than clay land, which has given rise to the following vulgar rhyme.

He that marles sand,
Will soon buy land;
But he that marles clay,
Throws all away.

The truth, however, is, that clay is as highly benefited by the calcareous matter in marle as sand is,—so that a rich marle will be nearly equally beneficial in both cases.

But, there are some kinds of clays that are very free from any mixture of sand, and assume the appearance of marle, and are so called, altho' they hardly contain almost any calcareous matter at all.—These may, perhaps, on some occasions, be an useful addition to light soils,
and

and worth the expense of carrying to them when near,—but could never be of almost any use at all upon clayey soils. It has probably been some poor kind of marle of this sort that has given rise to the proverb above quoted.

§ 32.

I shall not pretend to prescribe positive rules for determining when the one or the other of these substances, *lime or marle*, ought to be preferred as a manure; as a decision in favour of the one or the other, must in a great measure depend upon the situation of the place where they can be both obtained;—the purity of either of them respectively,—the price at which they may be purchased, and the expense of carriage;—all these circumstances may be best ascertained by every individual for himself.

But I may be allowed to observe, that it argues a great want of knowledge of the real qualities of these substances, when a man prefers the one of these and condemns the other in all cases. For it is merely a matter of calculation, *when* the one, or *when* the other may be most valuable to any particular person.

If the marle be tolerably rich, and can be obtained at little expence near the field, in the proportions usually employed;—it will be in general more advantageous to the possessor, who has a prospect of enjoying his farm for a long time, to use marle in preference to lime.

But, when it must be brought from a distance, *lime*, in all cases, will be cheaper, and on that account better, than *marle*.

If marle contains a great proportion of clay,—it might be worth the expence of driving to a light soil on some occasions, even where lime could be procured as cheap:—But, on all occasions, if the same quantity of calcareous matter in this state of lime can be obtained at the same price,—*that* will be a much more beneficial manure for clayey soils than marle.—Impure marle is indeed seldom worth the expence of carting on a clayey soil.

Some readers will be much dissatisfied at reading this short account of the nature of marle, and its operations as a manure.—For, as they have been accustomed to look upon this manure as possessing some very singular qualities peculiar to itself, and to think that it differed from lime in some very essential respects, and would produce effects upon the soil, nowise similar to that which would be produced by lime in any case;—they will feel a kind of uneasiness at being obliged to strike this one off their list of distinct

distinct and separate manures.—But it is the business of true philosophy, to eradicate that spirit for mysterious credulity, which is so apt to lull the reasoning faculty asleep, and make the mind rest satisfied with the contemplation of ideal phantoms created by the fancy, instead of real objects of useful knowledge.

§ 33.

Of Shell Marle.

Shell marle is always found in low places, that either are, or have been, covered with water. It is a whitish powder, that has been formed by the gradual decomposition of shells, in the course of many ages.—It is, therefore, a pure calcareous matter, without any other mixture than the mud, and other sediments that may have sunk to the bottom of the water, in the ponds where it has been formed.

As the proportion of sediment that may have mixed with the shells, may be very different in different situations; this kind of marle, like all others, may be more or less pure, and, of consequence, of greater or smaller value to the farmer.—Its purity may be determined by the mode prescribed page 287. and its value ascertained with precision.

It

It is usually a light, spongy substance, very slightly coherent, and contains more calcareous matter in proportion to its weight, than the common sorts of lime. And, as it admits of being spread as equally as lime, it may in general be carried with profit as far as lime.

But, as it is more spongy than lime, perhaps a smaller quantity will fill the measure; on which account, the prime cost of the same quantity of marle ought to be a little below that of lime, to be equally profitable to the farmer.

Shell marle, however, cannot be carried so far with profit as shell lime of the best sort; as this last, in that state, wants a great proportion of its moisture, air, &c. which greatly diminishes its weight.

It is, nevertheless, a very great treasure to those who can discover it, as it is almost in all cases of equal value with lime,—produces the same effect upon the soil,—admits of being equally easily spread, and can, for the most part, be obtained upon the spot at a much smaller expense.

But, in situations where fuel is scarce and dear, it is of much greater value than the best lime-stone,—and ought to be prized accordingly by every possessor of ground; nor ought any one, in such a situation, to omit searching diligently

ligently every place, where there is the smallest probability of finding it.

§ 34.

Of Shelly Sand.

On many parts of the sea-coast, great beds of shells are to be found, which have been broken into such small parts as to assume the appearance of sand. This is a rich and valuable manure, that deserves to be highly prized by those who are within reach of it; but, it is too often neglected and unobserved, as this kind of sand has, on many occasions, very much the appearance of ordinary sand.

This may readily be discovered, by pouring a little aqua fortis, or any other mineral acid*,

* Many persons make this trial with *vinegar*, instead of the mineral acids; but this ought never to be done, as it often happens, that vinegar makes no sensible effervescence with calcareous substances. I would, therefore, advise every country-gentleman, to keep a phial of aqua-fortis, or muriatic acid, always by him, for making trials of calcareous substances; the expense is nothing, and, I am persuaded, from the want of it alone, many persons have failed to make discoveries of calcareous matters, that might have been of high importance to themselves and families.

upon

upon the sand you wish to examine. If it contains shells, an effervescence will ensue; and the proportion of calcareous matter, contained in any sort of sand, may be ascertained by the same process already so often referred to, p. 287. Nor ought this trial ever to be omitted before the sand be employed as a manure; because, a very small proportion of shells will make it effervesce violently, so that the degree of effervescence is no proof of its purity,—and because the proportion of shells varies in all possible degrees.

If the shells are broken into very small fragments, and, if the proportion of sand is inconsiderable, it will be nearly as valuable as lime, and may be driven to a great distance with profit. If the proportion of sand be very great, the expense in using it will be greater, as the quantity must be considerably increased.

But, as it may, for the most part, be procured at little expense, those who are possessed of it, are usually able to employ it in great quantities; in which case, it will produce amazing effects, especially upon strong clay land.

A much smaller quantity of calcareous matter, in this state, will produce a more sensible effect, than when it is in any sort of earthy marle; because, it admits, of being more equally spread
upon

upon the ground, and more intimately mixed with the soil. Those, therefore, who are upon the sea-coast, ought to search for it with care, as they will usually obtain an invaluable treasure when they discover it.

This sort of sand is much more common in the east coast of Scotland, than is usually imagined.—All along the coast of Fife, especially about St. Andrew's, the sand upon the shore is richly impregnated with shells;—but it has never there been employed as a manure.—On the north coast of Aberdeenshire, shelly sand abounds, and has been of late employed as a manure with the greatest success, by a gentleman distinguished for his knowledge and public spirit in that corner.—It is likewise found in Banffshire, where it has been applied with the highest success.—And all along the coast of Sutherland and Caithness, the sands upon the shore consist almost entirely of shells.

These are treasures which will enrich posterity, altho' they are at present in a great measure neglected. I mention them here to induce my countrymen, not to neglect a treasure of such inestimable value.

The ingenious Mr. Craik in Dumfriesshire, —so well known for his judicious improvements in the drill husbandry, has, I am told, employed this manure for a longer time, and in greater quantities, than any other person in
Scotland,

Scotland, and has been highly benefited by it. I wish to produce such a respectable authority, with a view to induce others to follow his example.

§ 35.

Mr. Arthur Young, in one of his Tours, mentions a bed of shells near Colchester, in Essex, which the inhabitants distinguish by the name of *Cragg*, and employ as a manure with the greatest success. From his account of this substance, it would seem doubtful, whether it was a real calcareous matter or not. But he only tried it with vinegar,—an acid too weak to produce any sensible effect on many sorts of calcareous matters, in certain circumstances. There is little room to doubt, but that, with a mineral acid, the effervescence would have been sufficiently violent.

§ 36.

In some places there are found large beds of oyster shells almost entire. These are so large, as to require to be broken into smaller fragments, before they can be profitably employed as a manure.—And, as these may be easily calcined,

cined, they ought always to be reduced to the state of lime before they are used. Whoever finds a bed of these, finds a lime quarry of the most valuable sort, and ought to value it accordingly.

It may be sometimes necessary, to burn shelly sand into lime, and this may, on extraordinary emergencies, be practised, altho' it is rather a troublesome operation. For, as the incoherent sand always mixes with the fuel, and extinguishes the fire, when in its native state, it becomes necessary to reduce it first to some degree of consistency.—This may be effected by kneading the sand with a little clay, and moulding it into the form of bricks; which, when dried, will retain their form so long as to permit the fire to act upon the shells, and burn them to lime, which may be afterwards slaked and used. A manufacture of this kind is carried on at the Duke of Bridgewater's great works, near Warrinton, in Lancashire.

In situations where lime-stone cannot possibly be had,—and where the carriage of *lime* would be extremely expensive,—it may sometimes be adviseable, to burn some of this shelly sand into lime, for the *purpose of building*; but, if the lime is to be employed as a manure, it is a very idle and a useless process: For the burning, in this case, can only be of use in dividing the calcareous matter into small parts, which has
already

already been performed by nature, when the shells were reduced to the state of fine sand.

§ 37.

Of Lime-Stone Gravel.

This is a manure little known in Britain, altho' it is common in many parts of Ireland. It is a hard sort of marle, that assumes the appearance of small stones, or gravel,—which, when spread upon the ground, and mixed with it, gradually falls into smaller pieces, and fertilizes the soil in proportion as it breaks down and mixes with it.

After what has already occurred, little needs be said as to the qualities or mode of applying this manure; as the reader will easily be able to perceive, that, if the pieces of which this gravel consist are large, and dissolve but slowly, the quantity applied at one dressing ought to be great, and the effects will be slow and lasting;—and if the gravel is small, it will require a smaller quantity,—will operate more quickly, and last for a shorter time, like all other calcareous substances in the same circumstances.

These

These are all the varieties of calcareous matter, that I have ever known to be used as a manure. They are all extremely useful in proper circumstances,—perhaps equally so, if these circumstances are duly attended to. To assist the farmer still further, the following general aphorisms relating to the application of calcareous matters as a manure may be of use.

§ 38.

There seems to be only one kind of calcareous matter; and all the varieties of calcareous substances that we meet with, are entirely occasioned by a diversity in the nature of the extraneous bodies with which the calcareous matter is united, or a difference in the form it may appear in at the time.

Considered as a manure, these extraneous matters may be more or less beneficial, according to particular circumstances, relating to the soil, &c. In all the fossil calcareous concretions, clay or sand seem to be the only extraneous matters worth attending to,—neither of which can ever be of great consequence as a manure, altho' they may be more or less proper for different soils. In those calcareous substances

stances that belong to the animal kingdom, the fleshy parts of the animal may be, sometimes, united with the calcareous, which will greatly promote their effects as a manure, on every kind of soil whatever. This does not, however, seem to be the case, either with shell marle, or fine shelly sand; as, in both these cases, the animals, which once inhabited these shells, have been so long dead, that no part of the fleshy substance can remain. But the recent shells, obtained from fishing towns, operate much more powerfully as an animal manure, than as a calcareous matter, when first applied.

It is not impossible, but that man may, in time, fall upon some contrivance, for obtaining this animal calcareous manure, in much greater abundance and perfection, than it has hitherto been ever obtained. There is a small species of fresh water *wilk*, which encreases so fast, as in a surprising short time to fill a considerable space with solid wilks, if a few of them have been placed in a proper receptacle for that purpose, and water duly administered to them.— If then, ponds were prepared for this purpose, and properly stocked with this animal, and if they were allowed to increase, till a bed of them of considerable thickness was accumulated, might they not, then, be taken out in abundance to be employed as a manure? These, if
bruised

bruised under a stone like a tanner's wheel, to reduce the shells to small fragments, would certainly form as rich and efficacious a manure as could possibly be devised:—Nor could there be any difficulty in disposing the ponds in such a manner, as to afford a constant annual supply.

It has probably been by a natural process, similar to this, that all those beds of shell marle we now meet with, have been originally produced. This species of marle is generally found to consist of the shells of this sort of small wilk, or less decomposed. The animals which inhabited these shells, have been once nourished by the water contained in those hollow places where this sort of marle is always found, and have probably been entirely destroyed by some accidental drought, which deprived them of the water necessary for their existence, —or some other disastrous circumstance that it is impossible for us now to point out;—and the shells remaining behind, have gradually mouldered down to the state in which we now find them.

§ 39.

The same quantity of calcareous matter, will, in all cases, operate equally powerfully on soils of a similar quality, and in a similar state. But these effects may be accelerated or retarded,—be more uniform or unequal, according as the calcareous matter is more or less perfectly divided when it is first applied to the soil.

If the calcareous matter be divided into very small particles, so as to admit of being equally spread over a very large surface, a small quantity of it will produce a much more sensible effect, than if the same quantity of calcareous matter had been applied in large lumps, which could, in that case, have operated only upon a very few particles of the soil;—Therefore, *lime, fine shelly sand, or shell marle*, if equally pure, may be applied with profit, in much smaller quantities than any other class of calcareous manures.

Hence also it follows, that, if equal quantities of calcareous matter are employed as a manure, that which admits of being most minutely divided, will produce the greatest effect at the beginning; because, the separate particles will
be

be at liberty to act on a much greater number of particles of the soil at once, than when it is less perfectly divided.

But, if a sufficient quantity of calcareous matter has been applied, when in pretty large masses, so as to cover the ground pretty equally; and if these lumps continue to dissolve in the soil in all after periods, the effect of this dressing will be much longer perceived, than that of a dressing of calcareous matter in fine powder, that should produce at first an effect equal to this.—Perhaps, in this case, the virtue of every particle of the calcareous matter will come in time to produce a full effect upon the soil, and benefit it as much as an equal quantity of very fine powdered calcareous matter would have done, applied at different times. Stone and clay marles, therefore, are equally efficacious manures as powdered lime, altho' more slow in their operation.

But, as lime that has been suffered to run into solid cakes, before it is applied to the soil, can neither be properly spread upon it, nor has any chance of being dissolved by the action of the air afterwards,—it never can be made to produce its full influence on the soil; and therefore this mode of applying calcareous matter is the most unoeconomical that could ever be practised.

§ 40.

Calcareous matter, alone, is not capable of rearing plants to perfection,—mold is necessary to be mixed with it in certain proportions before it can form a proper soil.—It remains, however, to be determined, what is the due proportion of these ingredients for forming a proper soil.

We know that neither chalk, nor marle, nor lime, can be made to nourish plants alone;—and soils are sometimes found, that naturally abound with the two first of these to a faulty degree.—But, the proportion of calcareous matter in these, is so much larger than could ever be produced by art, where the soil was naturally destitute of these substances, that there seems to be no danger of erring on that side. Probably, it would be much easier to correct the defects of those soils in which calcareous matters superabound, by driving earth upon them as a manure, than is generally imagined,—as a very small proportion of it sometimes affords a very perfect soil. I shall illustrate my meaning by a few examples.

Near

Near Sandside, in the county of Caithness, there is a pretty extensive plain on the sea-coast, endowed with a most singular degree of fertility. In all seasons, it produces a most luxuriant herbage, altho' it never got any manure since the creation, and has been for time immemorial subjected to the following course of crops.

1. Bear after once ploughing from grass,—usually a good crop.

2. Bear after once ploughing,—a better crop than the first.

3. Bear after once ploughing,—a crop equal to the first.

4. 5. and 6. natural grass, as close and rich as could be imagined,—might be cut if the possessor so inclined, and would yield an extraordinary crop of hay each year.

After this, the same course of cropping is renewed. The soil that admits of this singular mode of farming, appears to be a pure incoherent sand, destitute of the smallest particle of vegetable mold,—but, upon examination, it is found to consist almost entirely of broken shells; the fine mold here, bears such a small proportion to the calcareous matter, as to be scarce perceptible,—and yet it forms the most fertile soil that ever I yet met with.

I have seen many other links (downs) upon the sea-shore, which produced the most luxuriant herbage, and the closest and sweetest pile of

grafs, where they consisted of shelly sand, which, without doubt, derive their extraordinary fertility from that cause.

A very remarkable plain is found in the island of *Tir-eye*, or *Tyre-ty*, one of the Hebrides.—It has long been employed as a common, so that it has never been disturbed by the plough, and affords annually the most luxuriant crop of herbage, consisting of white clover, and other valuable pasture-grasses, that can be met with any where.—The soil consists of a very pure shelly sand.

From these examples, I think it is evident, that a very small proportion of vegetable mold is sufficient to render calcareous matter a very rich soil.—Perhaps, however, a larger proportion may be necessary when it is mixed with clay, than with sand;—as poor chalky soils seem to be of the nature of that composition.

At any rate, however,—from these examples, as well as from those that have occurred in the preceding parts of this essay, I think we may be sufficiently authorized to conclude, that there is no danger of ever applying calcareous substances to any soil in an over proportion, if that soil was not originally impregnated with some kind of calcareous matters.

§ 41.

Calcareous matters act as powerfully upon land that is naturally poor, as upon land that is more richly impregnated with those substances that tend to produce a luxuriant vegetation.

Writers on agriculture have been long in the custom of dividing manures into two classes, viz. *enriching* manures, or those that tended directly to render the soil more prolific, however steril it may be,—among the foremost of which was reckoned *dung*,—*exciting* manures, or those that were supposed to have a tendency to render the soil more prolific, merely by acting upon those enriching manures that had been formerly in the soil, and giving them a new stimulus, so as to enable them to operate a-new upon that soil which they had formerly fertilized. In which class of stimulating manures, *lime* was always allowed to hold the foremost rank.

In consequence of this theory, it would follow, that lime could only be of use as a manure when applied to rich soils,—and, when applied to poor soils, would produce hardly any,—or even perhaps hurtful effects.

I will

OF QUICK-LIME

I will frankly acknowledge, that I myself was so far imposed upon by the beauty of this theory, as to be hurried along with the general current of mankind, in the firm persuasion of the truth of this observation, and, for many years, did not sufficiently advert to those facts that were daily occurring to contradict this theory—I am now, however, firmly convinced, from repeated observations, that lime and other calcareous manures, produce a much greater *proportional* improvement upon poor soils than on such as are richer.—And that lime alone, upon a poor soil, will, in many cases, produce a much greater and more lasting degree of fertility than dung alone.

As I concern myself little about theories, this discovery gave me much less uneasiness than it will give to some of my readers;—on which account, I shall not be much surprised if they withhold their assent to this proposition for a very long time.—I do not desire any one to agree to it, till their own observations extort assent to it,—which, I have no hesitation in saying, will sooner or later happen with every unprejudiced and attentive observer.

§ 42.

I shall conclude this very long essay, with a cautionary advice, that might, perhaps, have been more properly introduced before, if it had occurred at that time;—but it is of too much importance to be omitted entirely.—It is this.

When farmers employ a great deal of lime, it sometimes happens, that their horses feet are burnt by it, which is extremely troublesome, and sometimes proves even fatal to the poor animals *;—a method of preventing or remedying that inconvenience will therefore be of use.

The best method of preventing any inconvenience of this sort, is, to spread the lime, when in its powdery state, upon the field as evenly as possible,—and allow it to lie in that state for some time, before you begin to plough it.—If the lime has been in fine powder, it will have become perfectly *effete* in a week or so, after which time, it will be as little corrosive as any kind of common earth, so that the horses

* I have known several horses actually killed by this means, and others so disabled, as never to be perfectly well afterwards.

may

may work among it with perfect safety.—But, if it has been suffered to run into clods before it was spread, these, if not broken small, will be longer of absorbing their air, and, of consequence, will remain longer in an acrid state, so that the ploughing may, in that case, be deferred for a week or so longer; nor will it be even then so perfectly safe as the other.

But if it becomes necessary at any time to plow in the lime immediately after it is spread,—take care to do it only when the soil is perfectly dry; and in leading your horses to the plough, take care to prevent them from going through any wet place so as to wet their hoofs or ancles, for lime acts not at all upon any dry substance,—but, when it is in its acrid caustic state, it would corrode the hair and flesh in a moment, if it has access to water. As soon as the horses are unyoked, keep their feet dry till you have got them carefully brushed, so as to wipe away all the dry powdery lime that may adhere to them;—and, if the least shower should fall, unyoke your horses immediately, and carry them off the field.

With these precautions, they may work among caustic lime for any length of time without receiving any damage.

But, in case of any accident, by which a horse or man that is working among lime should be scalded by it, it is always advisable for every farmer

farmer who has work of that kind going forward, to keep a tub of very sour milk or whey in some place ready to wash the part affected well with it, which will quickly destroy the poignancy of the lime, and prevent the mischief that would otherwise arise from it.——

The sourer the milk or whey is, the better it will be for this purpose; it ought therefore to be long kept. For want of this, vinegar will produce the same effect,—or very stale urine will be of use;——but the milk or whey is the cheapest and best remedy, and ought to be always in readiness.

P O S T S C R I P T.

§ 1.

In the preceding essay, I have supposed that no other *absorbent** earth is ever mixed with the *calcareous* in any sort of lime-stone;—because, in fact, if ever any of these are mixed with the calcareous in these substances, they are in such small proportion as not to be worth regarding.—Those, however, who want to be critically exact in their analysis of lime-stone, may dis-

* Absorbent earths are all those that unite with acids, of which there are several varieties; calcareous earths being one of these.

cover if there is any other sort of absorbent earth contained in it, by dropping into the filtered solution obtained by the process, § 12. p. 286. a few drops of a clear solution of volatile alkali.—If no turbidness ensue, the calcareous earth has been pure.—If any precipitation takes place on adding the alkali, drop more,—and more, till no turbidness arises,—then filtre the whole ;—what remains in the filtre is absorbent earth that is not calcareous. For acids attract volatile alkali more strongly than any of the absorbent earths, except the calcareous class alone.

§ 2.

It may oftener happen, that a considerable proportion of gypsum may be united with lime-stone in the same quarry; and, as this substance would greatly alter the nature of the lime as a cement, (see p. 234.) and would probably affect it as much as a manure, it is of more importance to inform the reader of the easiest way of discovering this substance when it is present in lime-stone.

It has been already said, that gypsum is a compound, consisting of the vitriolic acid and calcareous earth; and, as the vitriolic acid attracts this earth more strongly than any of the
other

other acids, this composition is not in the least affected by either the nitrous or muriatic acids.

Hence, it follows, that if gypsum shall be contained in any calcareous mass examined by the process described § 12. p. 286. it will remain untouched by the acid, and be found in the filtre, after the calcareous earth dissolved in the acid shall have passed through it, forming a part of the *residuum*.

Take this residuum, therefore,—add to it nearly its own weight of fixt alkali * previously dissolved in a considerable quantity of water, and filtered;—digest it in a warm bath, or even boil it for some hours;—pour the whole into a filtre while yet warm;—as the fluid passes through the filtre, pour upon it more boiling water;—as that passes off, continue to add more water, till it comes through the filtre quite insipid and pure, and then let it run off entirely.

By this process, the vitriolic acid leaves the calcareous earth to unite with the fixt alkali, (to which it has a stronger attraction), and with it forms a vitriolated tartar;—this vitriolated tartar, and the superfluous alkali, are dissolved by the water, and carried through the filtre along with it, so that what remains behind is the ear-

* Potash,

thy part of the gypfum, and the heterogeneous matters contained in the original lime-stone.— By pouring upon this residuum, therefore, some nitrous or muriatic acid, and treating it as directed, § 12, p. 286. the calcareous earth that was in the gypfum, will be now entirely dissolved; so that, when it is filtred and dry, the difference between the weight of this *residuum*, and what it formerly was, is the real weight of the gypfum originally contained in the lime-stone.

N. B. If the alkali employed to decompose the gypfum was in a *mild* state, the calcareous earth that remains, will effervesce strongly when it is dissolving in the acid;—but, if a *caustic* alkali has been employed, the solution will be effected without any effervescence at all.

As vitriolated tartar is not readily soluble in water, a considerable quantity requires to be employed, which ought always to be hot, that the solution may be effected the more readily.

§ 3.

It has also been said (p. 193. § 5.) that the only extraneous matter contained in lime-stone is sand. But, altho' sand in general does predominate

dominate so much over the other extraneous matters in lime-stone, as to authorise the expression *in general*, yet there are some exceptions that ought to be taken notice of.

1st, There are some kinds of lime-stone, that, when analyzed, are found to contain a *residuum*, consisting of a soft slimy-like substance. This is always in very small proportions, and has probably been formed by a sediment subsiding from the water while the rock was forming. It seems probable, that this kind of lime would be less proper to be employed as a cement than as a manure.

2d, Altho' marle and lime-stone are justly enough distinguished in the text (p. 193. § 5.); yet, it happens, that clay and sand are found naturally mixed with one another in such various proportions, and in these states joined with calcareous matter, that there is no possibility of ascertaining the exact point where marle ends and lime-stone begins.

A very small proportion of clay is sufficient to make an exceeding hard lime-stone relent in time in the air, and fall to pieces; so that there are many sorts of stone marle that consist chiefly of sand and calcareous earth, and only a very little clay.

These very hard kinds of marle may be easily burnt into lime,—so that they may be indifferently called marle or lime-stone.

3d,

3d, The same may be said of the distinction between marle and chalk, (p. 193. §. 5.) Many substances, which have the appearance and distinguishing properties of chalk, contain clay in different proportions.—These dissolve in the air, or *run*, as it is termed, more readily than the pure hard kinds of chalk, and feel more unctious or fatty to the touch, from whence they are called *fat* chalks.—These, however, may be converted into lime, so that they might indifferently be called *chalk*, *marle*, or *lime-stone*.

The lime that is made from any of those substances that contain clay in their composition, is more proper for manure than for cement, especially that made from those substances that may be made to *fall* after they have undergone only a small degree of heat in calcining them, as in *chalk*; because, in these cases, the clay will not be sufficiently burnt to prevent it from being affected by water, and rendered soft by it.

The proportion of clay and sand contained in any lime-stone or marle, may be ascertained, by diffusing, in water, the *residuum* obtained by the analysis § 12. p. 286.—allowing it to subside a little, and gently pouring off the fluid parts from the coarser sediment that subsides to the bottom; for, as clay remains much longer suspended in water than sand, it may be thus separated from the sand entirely;—when
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the water comes off clear, after having been left to subside a little, the *residuum* may be evaporated to dryness,—and the loss of weight it has sustained by this operation, denotes the quantity of clay.

This is rather a mechanical, than a chemical process,—which is called *elutriation*.

§ 4.

It has been demonstrated above, p. 237. § 25. that the quality of lime, considered as a cement, is greatly altered, by being more or less perfectly calcined; it may therefore be, on many occasions, of use to those who are concerned in building, to be able to ascertain what proportion of any particular kind of lime is really reduced to a caustic state.—This may be done as under.

Take a known quantity of the quick-lime, perfectly dry,—add to that its own weight, or more, of common crude sal ammoniac*, previously dissolved in a large proportion of water, and filtered,—digest this nearly in a boiling heat for some hours, till no more smell of volatile alkali is found to arise from it,—adding fresh water as it evaporates. When the volatile alkaline smell is no longer perceived, throw the whole

* Observe, it is not volatile sal ammoniac.

into

into a filtre,—let that pass off,—add more hot water,—and more still, till it comes through the filtre tasteless and pure;—then dry the *residuum* and weigh it;—the difference between that and the weight of the original lime, denotes the proportion of pure caustic lime that was contained in the original mass.

For, as the muriatic acid attracts *caustic* calcareous earth more strongly than it does the volatile alkali, the acid of the sal ammoniac*, during the process, quits the alkali, and unites with the lime, and the alkali is suffered to fly off in a pungent vapour. The new substance formed by the union of the quick-lime with the muriatic acid, is called *liquid shell*; and, as this is readily soluble in water, it passes off, together with the remaining undecomposed ammoniacal salt, with the water through the filtre; while the uncaustic lime, as it was neither capable of acting upon the ammoniac, or of being dissolved in the water, remains behind in its solid state.

* Crude sal ammoniac, is a compound salt, consisting of the muriatic acid and the volatile alkali.

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THE END OF THE FIRST VOLUME.

